H. John · P. Wiklund
Editors

Robotic Urology

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Preface

Urology has traditionally been a technically driven specialty. Minimally invasive surgical procedures aim to reduce collateral surgical damage while optimizing functional and oncological results. Improvement of magnification, 3D imaging, articulated instruments, depth perception, and precise motor control are prerequisites to achieve these goals. Robotic technology has overcome most of these potential limitations and presently allows challenging laparoscopic interventions, not only in a few experts hands but also among a broad spectrum of urologists and patients who can benefit. Robot-assisted surgery presently operates on a "master–slave relationship basis," and the primary system is the Da Vinci robot (Intuitive Surgical, Sunnyvale, Calif.). Urology is the leading field in robotic surgery, with radical prostatectomy being the most often performed robotic-assisted intervention.

The birth of this instructional book is very timely, as many new robotic teams are experiencing their learning curve worldwide with great enthusiasm. The book highlights the standardized robotic procedures in urology. The authors have invested great effort and personal experience in order to support new robotic teams. As editors of this book, we tried to focus on the relevant urological procedures, knowing that the evolution of robotic urology will occur rapidly and involve many other urological operative indications in the kidney, ureter, bladder, and prostate surgery. Our thanks goes to Ms. Meike Stoeck from Springer, who helped to advance the project in a significant way. We are happy that our spontaneous idea to edit a textbook on robotic urology has come to a fruitful conclusion after 2 years of hard work. Personally (H.J.) I thank my teachers Peter Jaeger and Dieter Hauri for their influence and motivation in my clinical and research work during the past 15 years, and I am especially grateful to my wonderful wife, Manuela, for her support.

September 2007

Hubert John, Zurich
Peter Wiklund, Stockholm

Hubert John and Peter Wiklund in the Swiss Alps, 4 February 2006, when they decided to edit this book

Foreword

This book will show that robotic surgery already has a definite place in the daily work of operative urology. The book shows that robotic surgery is increasingly used in operations such as pyeloplasty, nephrectomy, urethral implantation, and, to some degree, in cystectomy. I focus on the most frequently performed operation in urological oncology: the radical prostatectomy (RP). Although I am personally fascinated by the new technology and fully aware that further improvements are forthcoming, I am reluctant to state that robotic radical prostatectomy is superior to open radical prostatectomy. Being involved now for many years in the surgical treatment of localized prostate cancer, I have experienced many alternatives claiming to stop open retropubic radical prostatectomy such as brachytherapy, perineal prostatectomy, and laparoscopic radical prostatectomy. In our prostate cancer center in Hamburg we offer a wide range of therapeutic options to each patient including seed implantation, high dose rate brachytherapy, external-beam radiation therapy, laparoscopic radical prostatectomy, and robotic radical prostatectomy. When patients are objectively informed about long-term side effects and cure rates, however, the majority of patients prefer not to undergo any such therapeutic options. The majority of patients choose open radical prostatectomy. I am aware that this is in contrast to recent developments in the United States, where 40% of all radical prostatectomies were done using the Da Vinci technique in 2006, and it is estimated that this will increase to 60 or 70% in 2007. I am also aware of the fact that approximately 60–70 Da Vinci systems are installed in Europe.

If we look at the Web homepages of centers that promote robotic radical prostatectomy, we get the impression that this technique is superior to the open approach. But what scientific evidence do we have for a comparison of the available techniques? Rojas-Cruz and Mulhall presented an abstract at the AUA meeting in May 2007 where they analyzed the stated advantages of robotic RP over open RP [2]. On 93 of 116 (80%) analyzed homepages it was stated that potency and continence rates achieved by the robotic approach are superior to open RP. Yet, only two (!) centers were able to give their own data on functional outcome, which demonstrates that scientific reality and arbitrary statements are presently in conflict with each other. The problem I have with such an approach is that we, as urologists, are able to judge such statements; however, a patient faced with prostate cancer seeking the best treatment is not informed in an ethically ideal way. Furthermore, this attitude will lead to high expectations of the patients, and I am convinced that many of them will be quite disappointed by the postoperative reality. At the same AUA meeting two groups presented a comparison of functional outcome of laparoscopic, robotic, and open RP. In both studies, which

included more than 1000 patients, open RP achieved slightly better results than the concurrent techniques [3, 4]. (By the way, I have not found this information on any robotic prostatectomy homepage.)

Will we ever have the chance to objectively compare surgical approaches? At present, it is not feasible, and I strongly believe that it is the surgeon who is the most important factor for a successful procedure. Multiple single-center experiences are published that do not allow drawing any conclusion as to whether or not a certain technique is advantageous regarding cancer control rates and functional outcome. Cancer control rates are definitely more influenced by tumor selection than by whether we control our instruments by hand or via a console. With regard to functional outcome, again it is the surgical technique and the principles in combination with the experience of the surgeon, rather than the instruments we are using [5]. The nerve-sparing procedure, for example, should be started ventrally, coagulation and tension on the neurovascular bundles should be avoided, etc. [1]. Obeying these principles is what is leading to adequate results regardless of the way we get our instruments down to the prostate.

In a recent study from the MSKCC it was furthermore shown that the surgeon's experience is not only associated with postoperative morbidity and functional outcome, but also with cancer control rates [6]. In this study based on 7765 prostate cancer patients, the learning curve for prostate cancer recurrence after RP was steep and did not start to plateau until a surgeon had completed approximately 250 prior operations. The predicted probabilities of recurrence at 5 years were 17.9% for patients treated by surgeons with ten prior operations and 10.7% for patients treated by surgeons with 250 prior operations (difference = 7.2%, <0.001). Again, the surgeon's experience is what counts most.

So what are the potential advantages of laparoscopic, robotic, and perineal RP over the open approach? If we look at invasiveness, it has been shown that the open approach is not more invasive than the laparoscopic one [7]. This is due to the fact that we approach the cavum retzii without any muscular incision which is a totally different situation, i.e., compared with kidney or adrenal surgery in which a clear benefit for the patient is shown for the laparoscopic approach [8]. Nevertheless, it is clear that blood loss is reduced in laparoscopic, robotic, and perineal RP compared with open RP; however, due to improvements of surgical technique and improvements in anesthesia (such as restriction in infusion intake), the transfusion rate in modern open series is negligible at present [1]. Hospital stay following RP is instead driven by the health system than by the surgical approach, and again we cannot really find an advantage of any technique. I could cite numerous papers which have investigated one or the other aspect of the various techniques, but such information seems undesirable at this point. Briefly, there is no real advantage of a laparoscopic or robotic approach over the open RP. Data on effectiveness which address long-term outcome comparable to that of open or perineal RP, however, need to be obtained.

A clear disadvantage for the robotic approach is obvious: as soon as cost-effectiveness is considered, all other available techniques are by far superior. At least in Germany this will play a major role for the development of this approach, especially in light of the fact that thus far no substantial advantage for the patient is apparent.

Where are we going from here? I believe that in the future we will have parallel techniques available. Actually, reflecting the German situation, this is what has already happened. In the past few years, in addition to retropubic and perineal prostatectomy,

the laparoscopic approach has been established. Few centers (including ours) have gathered their first experience with robotic RP, which is without a doubt a fascinating technique. With all the upcoming developments in robotic surgery, such as haptic feedback, the entire situation might be different 10 years from now, and maybe we will eventually see, in fact, that a surgical approach will make a difference. It is our task for the future to produce objective data which compare equally experienced surgeons for every technique. Our personal feeling, however, is that the surgeon's experience will remain the most important factor for success of RP in the future.

Hamburg, September 2007 *Prof. Dr. med. Hartwig Huland*

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Chapter

1 History of Robotic Surgery in Urology

András Hoznek

1.1 Introduction

In the present era of telecommunications and computer technology, the way we live and work in both our professional and private environment have radically changed. Within this frame, the concept of automation and robotics has been extensively used in several fields of industry or hostile working environments. It has also recently been extended to medicine including assistance in complex surgical procedures.

In this chapter, we recall the marked achievements of the past few decades which have led to gradual implementation of robotics in medicine and especially in urological surgery.

1.2 Background

The word robot, taken from the Czech word "robota," meaning forced work, was used the first time in 1920 by the Czech writer Karel Čapek in his science fiction play "Rossum's Universal Robots." In the story, an inventor created and sold robots as a cheap labor force to the world; however, once the robots became anthropomorphic and highly intelligent, having feelings and able to make decisions, they realized their physical and mental superiority. They declared war on all humans and destroyed the entire human race.

The very first time a robot was used to assist a surgical intervention was in 1985. Kwoh [1] et al. in the Memorial Hospital of Los Angeles brought the industrial Unimation PUMA 200 robot into the operative room to hold a laser for neurosurgical interventions. Neurosurgery was a favorable candidate for testing robotic devices because the skull offers constant spatial landmarks. Stereotactic frames were developed for the purposes of biopsy and cranial stimulation.

Surgical robots fit into three categories: active; semi-active; and the so-called master–slave systems. The active system consists of a robot performing tasks autonomously under the supervision of the surgeon. Semiactive systems have an autonomic- and a surgeon-driven component. Master–slave systems allow the surgeon to directly telemanipulate the robot from a more or less remotely placed command center. In this situation, the surgeon's movements are translated into robotic motion.

In urology, robots have been tested in two areas: endourology and laparoscopic surgery.

1.3 Endourology

1.3.1 Transurethral Prostate Resection

The earliest application of robotics to urological surgery began in 1989 with the group of the Mechanical Engineering Department at Imperial College in London. This group illustrated the ability of robots to perform precise, repetitive, and controlled tasks during transurethral resection of the prostate. They manufactured a prototype named PROBOT [2–4]. This is an autonomous robot, i.e., a system that executes surgical tasks following a preoperatively established plan. Firstly, the surgeon measures the distance between the bladder neck and verumontanum. Then, the prostate is scanned with an ultrasound probe passed into the resectoscope, allowing to build up a three-dimensional image of the prostate. Next, using this image, the surgeon designs on the computer console the cavity to be cut. The resection itself consists of cutting out a series of cones with the base of the cone at the bladder neck and the summit directed towards the verumontanum. PROBOT has been tested both in the laboratory and later on human subjects and has proved itself capable of performing prostate resection.

1.4 Ablatherm

A similar autonomous concept is used for the high-intensity focused ultrasound (HIFU) treatment of prostate cancer. The ABLATHERM device was created in 1993 at the Department of Urology and Transplantation, Edouard Herriot Hospital, Lyon, France, by Albert Gelet [5].

The device consists of a treatment and a control module. The patient is positioned on the treatment module. An ultrasound probe including the HIFU generator and the scanning equipment is attached to the treatment module via a mobile support; the latter executes robotic movements transmitted to the probe allowing delivering extremely precisely HIFU energy to preplanned areas of the prostate.

The control module enables the surgeon to first create the three-dimensional model of the prostate then plan and monitor the treatment via a computerized system which guides the robotic endorectal probe. The device is presently mass produced and validated for the treatment of prostate cancer in specific indications. By June 2005, the device was implanted to 76 sites worldwide and more the 7700 patients have been treated.

1.5 Prostate Biopsy

Based on the fixed position of the prostate within the pelvis, an Italian group developed a system which helps targeting transperineal prostate biopsies in 1995 [6, 7]. The SR 8438 Sankyo Scara robot allows accurate positioning based on the integration of ultrasound monitoring and the position and configuration of the patient's body recorded by four video cameras. This experience was the first telerobotic procedure in urology.

1.6 Percutaneous Renal Access

Percutaneous access creation during nephrolithotomy or other nephroscopic procedures is challenging and requires substantial skill and experience. Inaccurate placement of the needle may be at the origin of severe complications by injuring the kidney and adjacent organs; therefore, in many urology departments, these tasks are relinquished to interventional radiologists.

A robotic system to assist the urologist with intraoperative percutaneous renal access was developed at the Johns Hopkins University. In the first prototype, the surgeon selected the target calyx on a biplanar fluoroscopy screen and the LARS robot inserted the needle into the desired location [8]. In a preliminary series of 12 patients, successful access on the first attempt was observed in 50% of cases. Needle or tissue deflection accounted for each failure.

A further development of this tool led to the PAKY (Percutaneous Access to the Kidney) device, which consists of a passive mechanical arm mounted on the operating table and a radiolucent sterilizable needle driver that uses an active translational mechanism for needle advancement [9]. The system utilizes real-time fluoroscopic images provided by a C-arm to align and monitor active needle placement. A second component was more recently added to the system: the remote center of motion (RCM) device consists of an active robotic arm attached to PAKY that allows the tip of the needle to pivot about the fulcrum point on the skin [10]. This allows the urologist to correctly align the needle along a selected trajectory path under remote fluoroscopic control at the console. This minimizes radiation exposure to the surgeon's hand.

The success rate with this latest version of the device is 87% [10]. These preliminary results provide the foundations for the development of entirely automated robotically assisted percutaneous renal access.

1.7 Laparoscopic Surgery

The more popular platform for the application of robots in urology is laparoscopy. Since the early 1990s, laparoscopic surgery has aroused much interest in the field of urology and has become an integral part of daily practice in many specialized centers; however, the learning curve of laparoscopy is steep and for many established urologists in practice, fellowship training is unrealizable. The tremendous motivation to develop surgical robots stems from the desire to overcome the limitations of laparoscopic technology and to exploit the benefits of minimally invasive surgery.

1.7.1 Robotic Camera Holders

The voice commanded robotic manipulator AESOP (Automated Endoscopic System for Optimal Positioning) was conceived to control the laparoscope in response to the surgeon's instructions. This robotic camera holder eliminates the need for an additional member of the surgical team, reduces instrument collisions, and offers a steadier endoscopic view. This was the first surgical robot that got U.S. Food and Drug

Administration (FDA) approval for clinical use in the U.S. in 1994. Since its introduction, AESOP has assisted in more than 45,000 procedures worldwide.

Solo-surgical laparoscopic radical prostatectomy was shown to be feasible and reproducible by Antiphon et al. in 2003, and the procedure is routinely used in some centers [11].

1.7.2 Master–Slave Systems

Undoubtedly, the biggest conquest of robotics in urology and especially in the field of laparoscopy was achieved after the birth of master–slave systems. The development of such systems was the result of several decades of experimental research.

Telepresence surgery was originally developed to be used when interaction of the surgeon and patient is unfeasible or unsafe. Experiments were done with the view of performing open trauma surgery in the battlefield with the surgeon controlling the manipulators from a safe, distant location. Both the Pentagon and the North American Space Association (NASA) evaluated the potential for remote surgery.

A functional master–slave manipulator for surgery was constructed by Jensen and Hill (SRI International, Menlo Park, Calif.) [12]. The SRI telemanipulator had only four degrees of freedom in its first versions. It was intended to be used mainly for remote surgery through telecommunication links, with particular emphasis on hostile environments such as military applications [13]. The first applications of the SRI system to open surgery were described by Bowersox et al. [14] in 1996, who used it for vascular surgery in pigs. He described dissection of the common femoral artery and closure of a 3-cm arteriotomy with a running suture through the master–slave manipulator in nine experimental cases. With this study, Bowersox et al. were able to demonstrate the feasibility of delicate surgical manipulations, such as vascular suturing techniques, via a master–slave manipulator system; however, the SRI system, in the configuration used by Bowersox et al., does not solve the problem of limited instrument mobility since it provides only four degrees of freedom of motion; therefore, this robot was not suitable for laparoscopic surgery.

The explanation is that, during conventional laparoscopic procedures, the surgeon is faced with specific constraints such as:

1. Loss of two degrees of freedom because of inflexible instruments and fixed points of insertion
2. Limited tactile feedback
3. Mirroring of hand movements
4. Variability of motion scaling caused by working with long instruments through fixed entry points
5. Inaccuracy during delicate reconstruction because of amplification of natural hand tremor
6. Dissociated hand–eye coordination and lack of depth perception secondary to two-dimensional visualization.

Master–slave robotic interfaces have been developed to overcome the inherent limitations of endoscopic surgery. Contemporary robots are able to reproduce the wrist

movements of the surgeon inside the body and therefore restore all degrees of freedom. The stability and precision, motion scaling and tremor filtering offer almost microsurgical performance. The architecture of all master–slave systems is similar: it consists of a surgical console that is nonsterile and placed remotely to the patient, the endoscopic stack, and three or four robotic arms.

This new generation of robots is represented by the two presently commercialized master–slave systems, concurrently developed by Intuitive Surgical and Computer Motion. Both devices are characterized by six degrees of freedom making them appropriate for laparoscopic surgery.

Fred Moll and Robert Young founded Intuitive Surgical in California in 1995. Their first prototype was the "MONA" robot. It was with this system that, on 3 March 1997, robot-assisted laparoscopic cholecystectomy was performed for the first time in history at the St. Blasius Hospital in Dendermonde, Belgium [15].

The Da Vinci robot derives from MONA and is characterized with reduced bulk enhanced ergonomy and improved tools. The Da Vinci offers three-dimensional vision via binocular endoscopic imaging.

Shortly afterward, the ZEUS system (Computer Motion, Goleta, Calif.) came onto the market in 1998. This system combined an AESOP robotic camera holder with two additional table-mounted robotic arms. Initially, the ZEUS system had instruments with only four degrees of freedom similarly to standard laparoscopic instruments, but in 2002 MicroWrist instruments gained FDA approval. The first generation of ZEUS offered only traditional two-dimensional views, but later the system was completed by three-dimensional glasses.

The advantage of the ZEUS is that it can be combined with the telecommunication system Sokrates to enable remote surgery over intercontinental distances. Since 1994 surgeons and computer scientists at European Institute of Telesurgery (Strasbourg, France) and telecommunication and robotic engineers from Computer Motion have joined in a common effort aimed at verifying the feasibility of surgery over long distances. This project was articulated in several steps that ended on 7 September 2001 with the performance of the first transcontinental robot-assisted laparoscopic cholecystecomy performed by Jacques Marescaux operating in New York on a patient in Strasbourg. This intervention entered into the history of surgery as "Lindbergh Operation" [16].

1.7.2.1 Clinical Experience with Master–Slave Systems in Urological Laparoscopy

The optimal candidates for robotic surgery are procedures where microsurgical precision and advanced reconstructive skills are necessary. In addition, the incidence of the urological disease should be high enough so that a consistent surgical volume is available to develop and standardize the technique, as well as acquire and maintain skills; therefore, presently the more often performed procedures in urology are robotic-assisted prostatectomy, radical cystectomy, pyeloplasty, and live donor nephrectomy.

1.8 Radical Prostatectomy

Robotic-assisted radical prostatectomy derived from the experience gained with its conventional laparoscopic counterpart (R. Gaston and T. Piéchaud, pers. commun.) [17, 18, 19–22]. The first Da Vinci-assisted radical prostatectomy was performed by Binder et al. in Frankfurt, Germany, in 2000. The surgical technique was first described and published by Abbou [23].

Although several European centers published small preliminary series, high costs and lengthy operative time limited the spreading of this technology [24–27].

In the United States, in the institute founded by Vattikuti, Meni Menon succeeded in accumulating sufficient experience to overcome the learning curve and develop a highly standardized procedure, thus diminishing operative time and costs. He reported a structured program for learning robot-assisted laparoscopic radical prostatectomy [28]. Menon had no previous laparoscopy experience; he was mentored by G. Vallancien and B. Guillonneau, who had a series of over 600 laparoscopic prostatectomy cases. The operative time for robotic procedure decreased with experience and after 18 cases and reached the operative time of conventional laparoscopic prostatectomy performed by the mentors. Menon's experience is at the origin of widespread use of robotic radical prostatectomy worldwide.

Since this initial study, the possibility of skipping the step of laparoscopic training has been further documented. Ahlering et al. confirmed that laparoscopically naive yet experienced open surgeons are able to successfully transfer open surgical skills to a laparoscopic environment after 8–12 cases using a robotic interface [29].

This explains the tremendous popularity of laparoscopic radical prostatectomy worldwide: It is estimated that 9,000 and 18,000 cases were performed in 2004 and 2005, respectively. In the few years since the initial robotic radical prostatectomies were reported, this procedure has emerged as the single largest indication for the use of the robot.

1.9 Radical Cystectomy and Urinary Diversion

The more complex robotic procedure in urology is radical cystectomy. The worldwide initial case was reported by Beecken in Frankfurt am Main, Germany [30]. The orthotopic Hautmann-type neobladder was formed completely intra-abdominally. The technique of radical cystectomy is based principally on the experience of radical prostatectomy; however, only anecdotal reports and small series of less than 25 patients are available worldwide [31–34].

1.10 Pyeloplasty

The experimental groundwork for robotic pyeloplasty was performed by Sung and colleagues in the porcine model using the Zeus robotic system [35]. Subsequently, the initial clinical experience with robotic Anderson–Hynes pyeloplasty was performed in Innsbruck, Austria, on a series of nine patients and reported by Gettman et al. [36]. The overall operative time was 139 min and the anastomotic time 62 min. Later, the

same group demonstrated in a comparative study that Da Vinci-assisted procedures are significantly shorter than standard laparoscopy [37].

1.11 Live Donor Nephrectomy

Laparoscopic donor nephrectomy successfully removes many disincentives to live kidney donation, resulting in an increased willingness of individuals to donate their kidneys. But the benefits are achieved only after a significant number of cases because of the complexity of procedures, time constraints, and the learning curve.

The first telerobotic simple nephrectomy in a human was performed by Guillonneau et al. using a Zeus robotic surgical system [38]. But live donor nephrectomy requires a more meticulous dissection. Furthermore, patient morbidity should be minimized particularly because this surgery is performed on otherwise healthy individuals.

In 2002, Horgan reported the first ten successful cases of robotic-assisted laparoscopic living donor nephrectomies using the Da Vinci system in the University of Illinois at Chicago [39]. Since this original report, in many centers where master–slave robots are available, performing robot-assisted live donor nephrectomy became a pragmatic choice.

1.12 Future of Robotic Surgery

Despite increasing interest and the development of procedures with proven safety and feasibility, many surgeons believe that robotics is “not ready for prime time” at most centers. This is explained by technical limitations and financial barriers.

It is not unrealistic to expect, however, that surgical robots will undergo a development similar to other fields of computing and telecommunications. The world’s first gigabyte-capacity disk drive, the IBM 3380, introduced in 1980, was the size of a refrigerator, weighed approximately 250 kg, and cost US$40,000. Such storage capacity is now available as a pocket-size USB drive and costs less than US$20. In many fields of contemporary medicine, routine practice has become inconceivable without computer-based systems. For example, surgeons consider computed tomographic data to be more reliable in making diagnoses than classic information such as physical examination, symptoms review, or history taking.

But robots go beyond the category of specialized surgical instruments. The emerging combination of high-precision robotic manipulators and new cross-sectional imaging techniques opens the horizon of presurgical planning with the help of a virtual model or the use of augmented reality during surgery.

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Chapter 2

Surgical Anatomy of the Prostate for Radical Prostatectomy

Arnauld Villers
and Thierry Piechaud

2.1 Introduction

This chapter on prostate surgical anatomy for radical prostatectomy describes anatomic points and practical surgical options of dissection. Clear understanding of the periprostatic fascia helps in identifying the correct planes of surgical dissection and in communication between surgeons. Anatomic definitions and illustrations come from literature review and by use of specimens from fresh autopsy material, pelvic magnetic resonance images (MRI), and intraoperative photography. The surgical removal of prostate cancer and part of the adjacent visceral and parietal fasciae in an en-bloc package lessens the risk of local recurrence due to residual tumor.

2.2 Pelvic Fasciae, Parietal and Visceral, and Their Surgical Importance

The pelvic fasciae are either parietal or visceral (fascia pelvis parietalis, fascia pelvis visceralis, TA) [1]. The parietal comprises the endopelvic fascia which covers the anterior prostatic surface, the lateral parietal fascia which covers the levator ani laterally, and the fascial tendinous arch of the pelvis (arcus tendineus fasciae pelvis). The visceral fascia comprises the connective fatty tissue, with neurovascular supply located beneath the parietal fasciae. It covers and is adherent to all surfaces of bladder, prostate, seminal vesicles, rectum, and pudendal vasculature. Its thickness varies according to the amount of vessels and nerves it contains. Consequently, this so-called visceral fascia is not a discrete structure but rather a connective and mainly adipose thick structure which does not fulfill the fascial definition. A fascia is a discrete organized structure which can be grasped, identified on dissection, and separated as a whole from adjacent tissues. It has a function of covering, of enveloping membrane. It is made of connective layers of mesenchymal tissue (muscle and fibrous fibers). It is different from a sheath of adipose tissue surrounding neurovascular structures (as in the retroperitoneum or pelvic spaces). Surgical anatomy is based on gross tissue identification. The parietal fascia, e.g., endopelvic fascia, fulfills the fascial definition. It can be divided sharply and released as a whole from adjacent structures. Whereas refer-

ring to this adipose multilayered tissue of the so-called visceral fascia as a fascia is not very convincing, it cannot be released as a whole from adjacent structures since it is adherent to the visceral pelvic organs such as bladder wall or prostatic stroma without entering into their muscular and fibrous fibers stroma. In that sense, one can refer to the so-called visceral fasciae as an adipose meso- or visceral fibrofatty sheath containing neurovascular supply to intrapelvic organs and corpora cavernosa.

2.2.1 Parietal Fasciae

The fascial tendinous arch of the pelvis (arcus tendineus fasciae pelvis, TA) results in a thickening of parietal and visceral components of the pelvic fascia and stretches from the pubovesical (puboprostatic) ligaments to the ischial spine. When the levator ani (parietal or endopelvic) fascia is incised just lateral to the fascial tendinous arch of the pelvis, the bare levator ani muscle that overlies the obturator internus above and the ischioanal fossa below appears laterally.

2.2.2 Visceral Fasciae

Underneath the remnant levator fascia on the lateral surfaces of the prostate, the prostate visceral fascia where it is multilayered contains fat, smooth muscle, and collagen fibers. It is easier to identify grossly when nerves and vessels run among its layers. It consists of three subdivisions (according to its location): (a) anterior prostate visceral fascia associated with the isthmus or anterior commissure of the prostate; (b) lateral prostate visceral fascia, which covers the lateral glandular prostate; and (c) posterior prostate visceral fascia known eponymically as Denonvilliers' fascia (septum rectovesicale, TA). The foregoing terminology does not capture the continuous sweep of the fascia from the posterior surface of the prostate superiorly over the posterior surfaces of the seminal vesicles (Fig. 2.1). We propose herein "prostatoseminal vesicular fascia" (PSVF) to describe anatomically this posterior fascia, which is neither rectal nor a septum [2]. The PSVF is separated from the rectal fascia propria by a prerectal cleavage plane, which trails distally from the variable distal end point of the peritoneal cul-de-sac (rectovesical pouch; Fig. 2.2). This cleavage plane is a remnant of the two peritoneal layers that fused and disappeared before birth. On the posterior surface of the prostate, the PSVF has no macroscopically discernible layers [3–5]. Distally, the PSVF thickens and is demonstrably multilayered just distal to the prostatourethral junction. The PSVF extends posterior to the prostate apex and sphincteric (membranous) urethra and, as a terminal plate [6], has direct continuity with the midline raphe ending in the perineal body or central tendon of the perineum. The rectourethralis is not part of radical retropubic procedure. The final posterior cut at the prostatourethral junction is through the "terminal plate" of Denonvilliers' (prostatorectal) fascia. In contrast to the posterior surface of the prostate, the PSVF is frequently multilayered over the seminal vesicles (predominance of smooth muscle fibers which are seen grossly), but is, with only very rare exception, a single layer of fascia over the immediate posterior surface of the prostate [4, 7–9]. It has been suggested to distinguish a fascial leaf anterior to the seminal vesicles and a fascial leaf posterior to the seminal vesicles and prostate [10]. The anterior leaf has been referred to as vesicoprostatic muscle [11]. Posterolater-

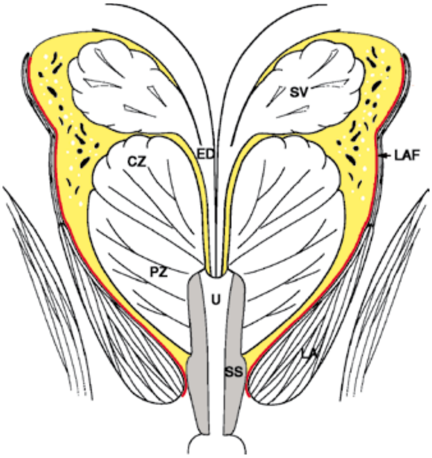

Fig. 2.1 Coronal section of prostate and periprostatic fasciae. *ED* ejaculatory ducts, *LAF* levator ani fascia, *SS* striated sphincter, *SV* seminal vesicles, *U* urethra, *PZ* peripheral zone, *CZ* central zone, *LA* levator ani

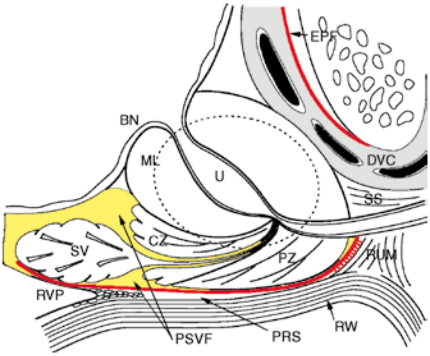

Fig. 2.2 Sagittal section of prostate and periprostatic fasciae. *DVC* dorsal vascular complex, *SS* striated sphincter, *RW* rectum wall, *PRS* prerectal space, *PSVF* prostatoseminal vesicular (Denonvilliers') fascia, *RVP* rectovesical pouch, *EPF* endopelvic fascia, *CZ* central zone, *PZ* peripheral zone, *U* urethra, *ML* median lobe, *RUM* recto-urethralis muscle, *SV* seminal vesicles

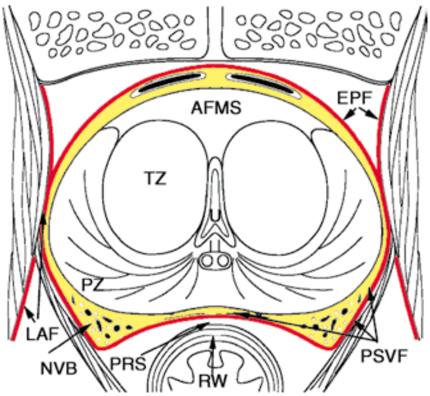

Fig. 2.3 Axial section of prostate and periprostatic fasciae at mid gland. *AFMS* anterior fibromuscular stroma of McNeal, *EPF* endopelvic fascia, *PSVF* prostatoseminal vesicular fascia, *RW* rectum wall, *PRS* prerectal space, *NVB* neurovascular bundle, *LAF* levator ani fascia, *PZ* peripheral zone, *TZ* transition zone, *U* urethra

ally, the neurovascular bundle (NVB) is embedded in PSVF, and medial to the levator fascia, which passes lateral to the bundle (Fig. 2.3); thus, in axial or transverse histological section, the NVB is bounded by a triangle of fascia as illustrated by Kourambas and colleagues [12]. The radical prostate specimen should be covered with Denonvilliers'

fascia particularly at the prostatoseminal vesicular junction because this is a location for the early extraprostatic extension of cancer.

2.2.3 Fascial Surgical Dissection

After the endopelvic fascia is opened, there are two lateral fasciae on the sides of the prostate:

1. The most superficial (single layer and parietal in origin) and first encountered belongs to the levator muscle that has just been displaced laterally.
2. The underlying fascia multilayered is the prostatic (visceral) fascia that tethers the nerve and vascular bundles to the prostate.

As the levator muscle is displaced laterally to expose the lateral surfaces of the prostate, its fascia remains abandoned and adherent to the outer lateral surfaces of the prostate. This remnant levator fascia overlying the outer surface of the prostate (Walsh's lateral pelvic fascia) extends in a posterior direction continuously over the neurovascular bundle (NVB) and the rectum and distally over the prostatourethral junction and its surrounding vessels [14].

In the antegrade approach for NVB preservation, levator ani parietal and endopelvic fasciae may not be incised. In this case, levator fascia, stays adherent to levatory ani muscle and progression within the inner aspect of this fasciae avoids its incision anterior and parallel to the NVB in order to preserve it. This dissection is often seen in live surgery. No layers of connective tissue are left on the specimen as nothing can be grasped with a forceps on the specimen surface, which by definition confirms that the glandular prostatic surface is at the margin.

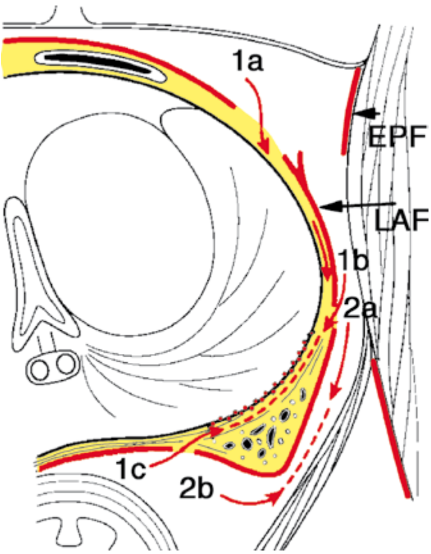

Fig. 2.4 Transverse section of prostate and periprostatic fasciae. The EPF was incised and LA muscle fibers were released from LAF. The prostate gland with LAF was tilted and deplaced medially, exposing its lateral surface. Various options of dissection are illustrated. Incision of LAF (*1a, 1b, 1c*) allows intrafascial dissection and NVB sparing with partial ablation of all the layers of the so-called visceral fascia (interfascial, *dashed line*) or complete ablation in contact with prostatic capsule (endofascial, *dotted line*). Extrafascial dissection (*2a, 2b*) would encompass all layers of periprostatic parietal and visceral fasciae. *EPF* endopelvic fascia, *LAF* levator ani fascia

For wide resection to include the NVBs and the prostatoseminal vesicular (Denonvilliers') fascia (see below) together with the specimen, this fascia must be incised posterior and parallel to the nerve bundle (Fig. 2.4). After dividing the posterior bladder neck, this fascial leaf anterior to seminal vesicles is a landmark with particular interest in difficult cases such as BPH median lobe, or bleeding [11]. The extrafascial dissection plane is anterior to this fascial leaf, towards the distal part of seminal vesicles and vas deferens.

2.2.4 Nerve-sparing Technique

As definitions of intrafascial (interfascial and endofasial) and extrafascial dissection, based on these observations, we propose, from an anatomic standpoint with respect to surgical dissection of the prostate, the following:

1. Extrafascial plane of dissection would define the prostate removed with all layers of visceral fibrofatty sheath present on the specimen (wide resection).
2. Intrafascial plane of dissection would define some portion of the so-called visceral fibrofatty sheath being present on the specimen with prostate capsular and glandular tissue at the margin.

In this type of intrafascial plane, one has to differentiate: an (a) interfascial plane (or partial visceral fibrofatty sheath ablation) of dissection, when, as the prostate is excised, layers of visceral fibrofatty sheath remain on the posterior surface of the prostate, but at any location or, for example, at the posterolateral surfaces of the prostate where the NVB's resident specimen is covered by visceral adipose layers; and (b) endofascial plane (or complete visceral fibrofatty sheath ablation) of dissection when at any location the specimen is without PSVF. Fascia then will be left covering the medial aspect of the NVB as the NVB is dissected away from the posterolateral prostate (Fig. 2.4). In the case of a partial intrafascial dissection with partial fascial removal (interfascial plane of dissection), a safety zone of complete so-called visceral fascia covering will be present on the specimen, thereby reducing the risk of positive posterolateral surgical margins. This is important because perineural tumor extension has been shown to involve microscopic posterolateral nerves to the prostate in the area of the NVB. This is the main mechanism of extraprostatic extension, and an important factor for positive margins [6, 9, 13].

During dissection, scissors may progress within the thickness of this visceral sheath, leaving some layers on the gland and some on the side of the parietal fascia. Small perforating vessels and nerves to the prostate are divided at that time. The amount of connective tissue layers preserved depends upon the location on the prostate surface and upon the size of the gland. For example, at the anterolateral aspect of the gland the visceral sheath is 2 mm in normal glands and 1 mm in enlarged glands, and once a layer of 0.5–1 mm of areolar fatty and fibrous tissue has been left on the gland surface, the remaining thickness left on the lateral side adherent to the parietal fascia is almost absent or less than 0.5 mm. These thin layers of connective tissue are left on the specimen and can be grasped with a forceps, which by definition confirms that the glandular prostatic surface is not at the margin.

2.3 Proximal Bladder Neck Sphincter and Detrusor Apron

There is only one sphincter at the bladder neck. Loss of anatomic integrity and compromised neural innervation must then contribute to the observation that the bladder neck never regains normal sphincteric function in the postoperative period. Attempts to preserve the bladder neck during RP may expose cancer if located at the anterior margin [13]. From the bladder neck to approximately the mid-anterior commissure of the prostate, the anterior surface of the prostate is covered by outer longitudinal smooth muscle of the bladder in a layer, a detrusor apron, that extends distally to end as two pubovesical ligaments on either side of the pubic symphysis (Fig. 2.2) [15]. The bunching maneuver over the anterior commissure of the prostate allows hemostasis of the anterolateral pudendal plexus as well as significantly increasing visibility of the adjacent anterolateral surfaces of the prostate for the purpose of subsequent NVB preservation. Furthermore, the bunching facilitates control of any anastomotic veins (and there is pronounced variability) traversing the lateral surface of the prostate from NVBs to the anterolateral plexus [15].

2.3.1 Urethral Stump (Sphincteric Urethra) Preservation

Variations in apical configuration of the prostate affect the exit of the sphincteric (membranous) urethra from the prostate. [15]. Laterally, thickened fascial band components of the DVC called Walsh's pillars or [16] Müller's ischioprostatic ligaments [17] provide insertion for the anterior layer of the striated sphincter (Fig. 2.5). Posteriorly, there is a variably thick fibrous tissue raphe striated sphincter into which is inserted into the circular component fibers of the horseshoe-shaped striated sphincter [18].

2.3.2 Prostatic Capsule

There is no prostatic capsule. The structure that we call the "capsule" is a transversely arranged fibromuscular layer that is recognized at the outermost region of the prostate

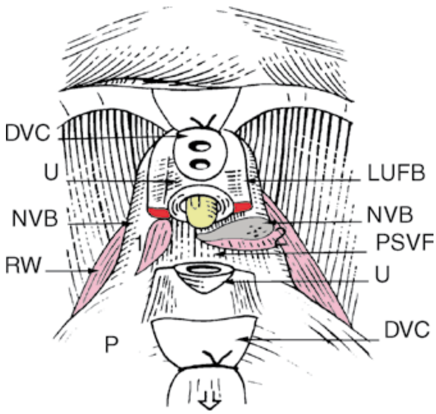

Fig. 2.5 Retropubic view after endopelvic fascia was incised and levator fascia (lateral pelvic fascia of Walsh) was removed from lateral surfaces of prostate. The dorsal vascular complex (*DVC*) and urethra are divided to allow exposure of the prostatoseminal vesicular (Denonvilliers') fascia (*PSVF*) terminal plate containing the neurovascular bundle (NVB) in its lateral part. The PSVF is divided sparing NVB (one left side) or dividing the NVB (two right side). *LUFB* lateral urethral fascial bands, *RW* rectum wall, *P* prostate

surface, but [19] at the posterolateral apex or base and at the bladder neck. Vessels and nerves, coursing within this adipose tissue, enter into the prostate at these areas; thus, the so-called capsule does not exist due to merging with the so-called visceral fascia, which is adherent to the prostatic stroma. These transversely arranged fibromuscular layers contain the spread of cancer [9]. Consequently, there is always peril at the apex. In the absence of BPH it is sometimes difficult to define the prostatourethral junction.

2.3.3 Rectourethralis

The rectourethralis is a fibromuscular complex that produces anterior angulation of the anorectal junction as noted above. It consists primarily of a dominant (more substantial) midline component of smooth muscle from the anterior wall of the anal canal coming from below (anoperinealis, TA) and a less dominant midline component of smooth muscle from the anterior wall of the rectum coming from above (rectoperinealis, TA). These two components then converge from below and above, respectively, and insert into the perineal body (central tendon of the perineum; Fig. 2.2). There is no direct urethral attachment. Importantly, the attachment anteriorly is distal to the posterior apex of the prostate and therefore the rectourethralis is not part of the retropubic operation as it is in the perineal operation. Descriptions of the retropubic operation often mistakenly describe transection of the rectourethralis after urethral transection when what is being described is actually transection of the termination of the PSVF as it joins the midline fibrous tissue raphe of the perineal body. The rectourethralis attachment varies considerably in bulk from thick to thin [9]. Ukimura and associates have recently recommended the use of real-time ultrasonography during laparoscopic radical prostatectomy in order to assess apical configuration including the important posterior lip variant mentioned above [20].

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Chapter

Robotic Radical Prostatectomy: Extraperitoneal Approach

Hubert John

3

3.1 Introduction

Robotic surgery offers distinct advantages over conventional laparoscopy, such as six degrees of freedom, dexterity enhancement, stereovision, and tremor filtering. The technique of robotic prostatectomy has been described primarily using a transperitoneal approach in 2001 [1, 2].

The extraperitoneal approach for conventional laparoscopic prostatectomy was proposed by Raboy et al. 1997 [3] and popularized by Bollens et al. [4], Hoznek et al. [5], Dubernard et al. [6], and Stolzenburg et al. [7]. The feasibility of an extraperitoneal access for robotic surgery was reported in 2003 by Gettman et al. [8]. The extraperitoneal approach mimics the open retropubic technique and potentially prevents intraperitoneal complications. This chapter reports the technique of the extraperitoneal approach as it has been standardized in over 300 procedures [9].

3.2 Extraperitoneal Approach: Step by Step

The patient under general anesthesia and full relaxation is placed in a supine position on the operating table. The legs are slightly abducted and are fixed into the padded receptacles (Fig. 3.1). The arms are fixed beside the body in arm padding. A 20-F Foley catheter is inserted. The skin is incised over 2 cm transversely just below the umbilicus. With two Langenbeck retractors, the anterior rectus fascia is freed from the fatty tissue. The anterior rectus sheet is incised vertically over 1 cm (Fig. 3.2). The two Langenbecks divide the rectus muscle and expose the posterior layer of the rectus sheet. The preperitoneal space is than freed by blunt finger dissection and further developed with a balloon trocar (Tyco, Norwalk, Conn.) that is inflated (Fig. 3.3). The balloon is filled by 10–15 pumping actions, until the extraperitoneal space is appropriately created. Balloon dilation must be carefully performed to avoid bladder ruptures that have occurred in cases of overdilation. The first 8-mm robot trocar (Intuitive Surgical, Sunnyvale, Calif.) at the left side (Fig. 3.4) is bluntly introduced between the subumbilical incision and the left anterior iliac crest, about 1 cm lower than the optical trocar incision. Then, the 12-mm optic trocar (Ethicon, Norderstedt, Germany) is introduced and the insufflation is started (high flow, maximal intraabdominal pressure

Fig. 3.1 Patient positioning and monitoring. The patient is placed in supine position, with the legs slightly abducted. The legs are fixed with towels, in padded channels. Monitoring is achieved by a O_2 saturation (*arrow*) at the right big toe, and arterial catheter (*arrowhead*). A central venous monitoring is not routinely necessary

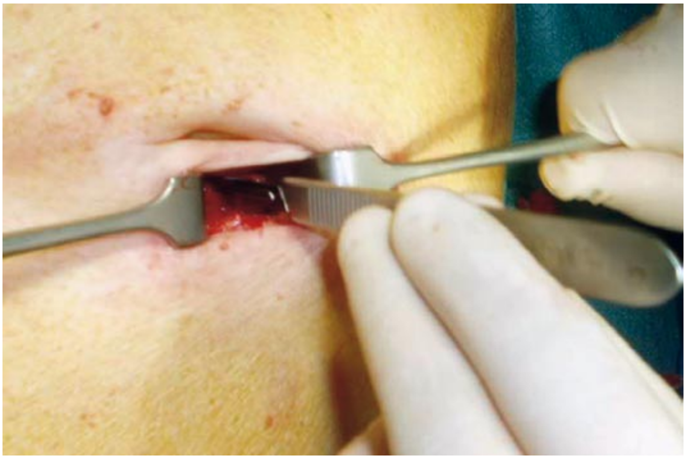

Fig. 3.2 Incision of the anterior rectus fascia. After the infraumbilical incision is performed and the fascia is exposed by the Langenbeck retractors, the anterior rectus fascia is incised vertically over approximately 1 cm

12 mmHg). An inspection of the extraperitoneal space is performed. The 0° 3Dendo-camera is introduced (Fig. 3.5). Under direct vision, the camera can be used to increase the size of the extraperitoneal space by gently sweeping the peritoneal borders laterocranially. The extraperitoneal exposure is expanded by circular movements of

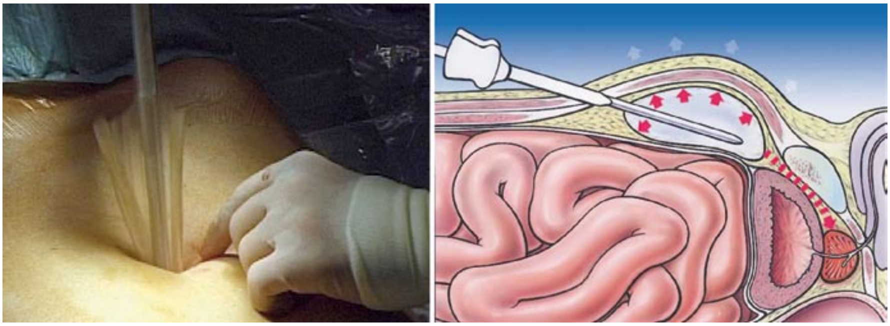

Fig. 3.3 Balloon dilation of the extraperitoneal space. After a 2-cm infraumbilical transverse incision, the balloon trocar is inserted and the pre-peritoneal space is created. Direct access to the bladder and prostate is achieved

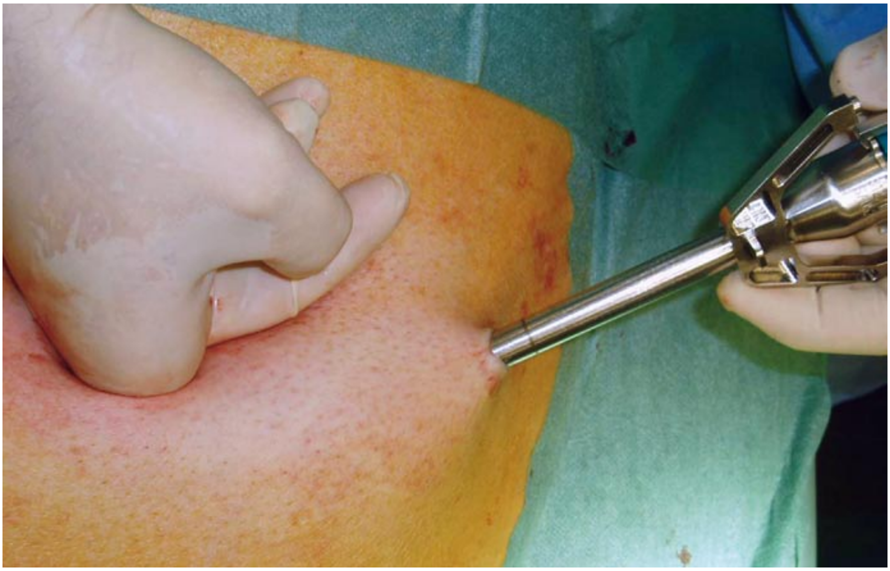

Fig. 3.4 First robotic trocar placement. The tip of the right index finger guides the blunt obturator tip of the 8-mm robotic trocar down into the extraperitoneal space, which has been created by prior balloon dilation

the tip of the camera and the optical trocar until the second 8-mm robot trocar can be placed under visual control (Fig. 3.6). Performing an extraperitoneal approach, the robotic trocars are placed about 1–2 cm caudal to the camera port. The 10-mm disposable assistant trocar (Versaport, Ethicon, Norderstedt, Germany) at the right side is placed just craniomedial of the right anterior iliac crest. Finally, the 5-mm assistant trocar is placed in between, but about 2 cm cranial to the right robotic and the optic trocar. The abdominal wall is slightly lifted by the camera-arm trocar ("laparo-lift").

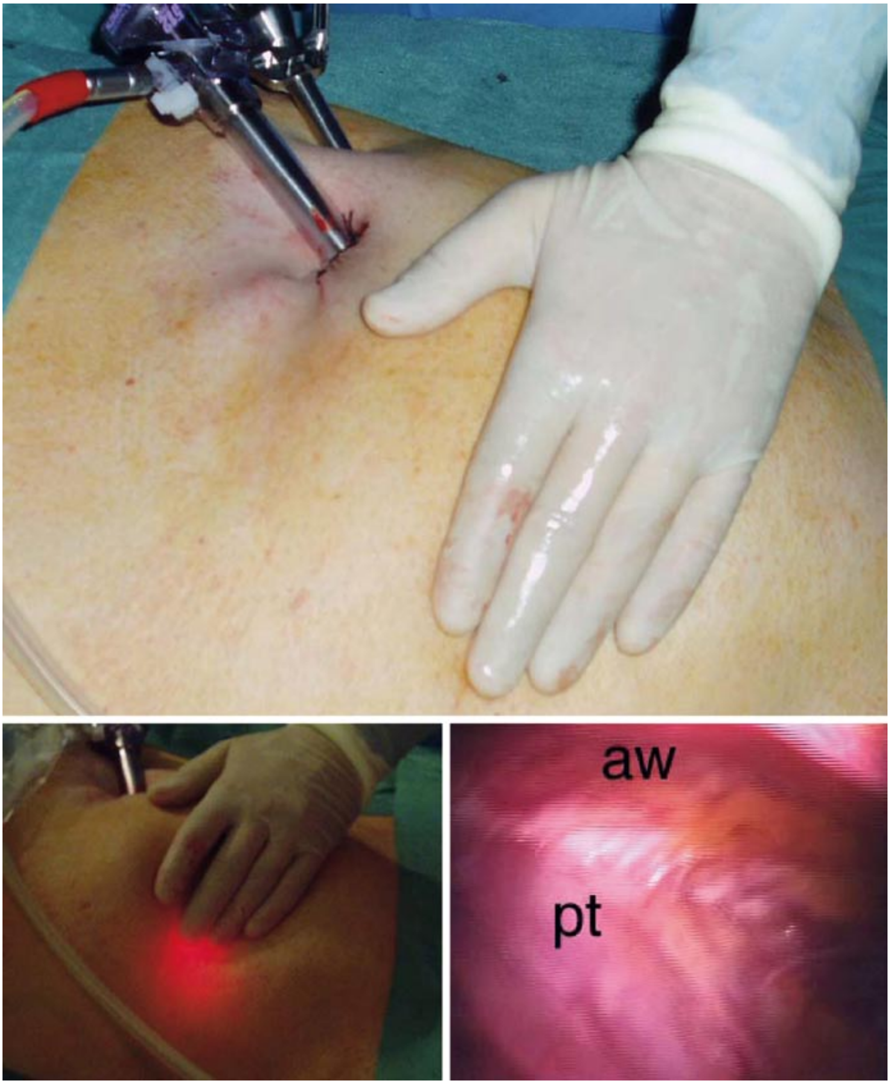

Fig. 3.5 Expanding the extraperitoneal working space. Under illumination, the camera can be used to enlarge the extraperitoneal space by gently sweeping the peritoneal borders to the side and upwards. *pt* peritoneum, *aw* abdominal wall

Alternatively to the right-sided 5-mm trocar, a 10-mm trocar can be introduced medial of the left iliac crest in the two-assistant situation (Fig. 3.7). We usually do not need another 5-mm suprapubic trocar which some groups introduce routinely during the intervention.

Minimal Trendelenburg position is required (15°), the robot is placed between the legs, and the robot arms are attached to the trocars. Both arms are connected and the

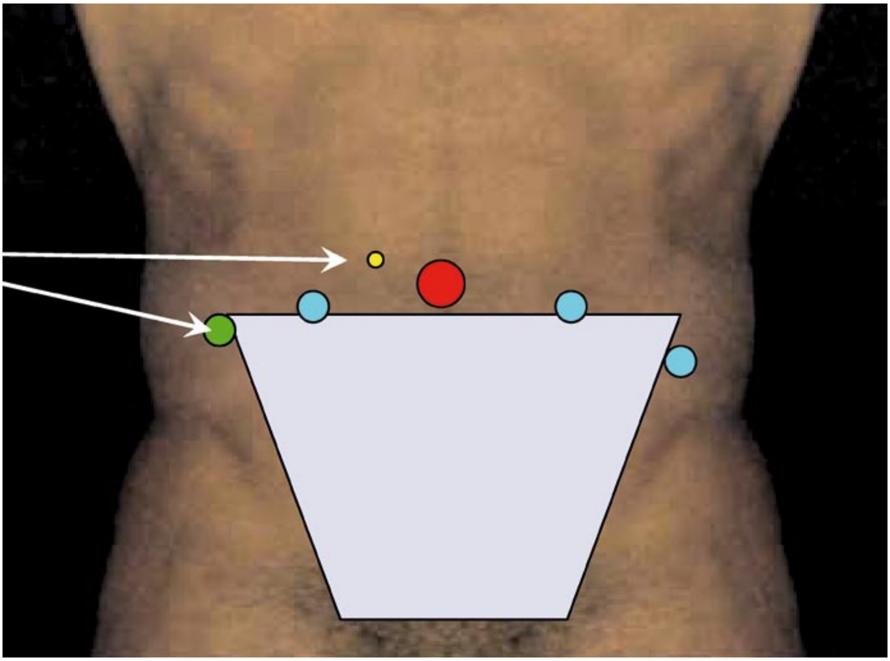

Fig. 3.6 Port placement in extraperitoneal robotic prostatectomy. *Red circle* laparoscope port (12 mm); *blue circle* robotic ports (8 mm); *green circle* assistant ports (12 mm); *yellow circle* assistant ports (5 mm)

EndoWrist (Intuitive Surgical, Sunnyvale, Calif.) instruments (bipolar forceps on the left side and curved scissors on the right) are inserted under visual control. The bipolar cable is attached onto the forceps. (Before starting with the operation, always ensure the lower extremities are not compressed by the robotic arms.) The console surgeon leaves the operating table after port placement and is not sterile scrubbed during the remaining procedure.

Usually, the console surgeons works with the pyramid tip (PreCise) or Maryland forceps at the left side and the cold or hot scissors at the right side. Two needle holders are used to tie. Some surgeons suture with one needle holder and a forceps. An aspirator serves the operating field from the 10-mm trocar from the left side. The intra-abdominal CO_2 pressure is regulated at 12 mmHg but may be increased during the dissection of the Santorini plexus to 18 mmHg to avoid bleeding in this phase and is reduced to 8 mmHg at the end of the procedure to check hemostasis.

3.3 Discussion

3.3.1 Patient Positioning

Slightly abducted legs allow positioning of the robot in between the legs and ensures the access to the perineum and rectum if necessary during the procedure. Trendelen-

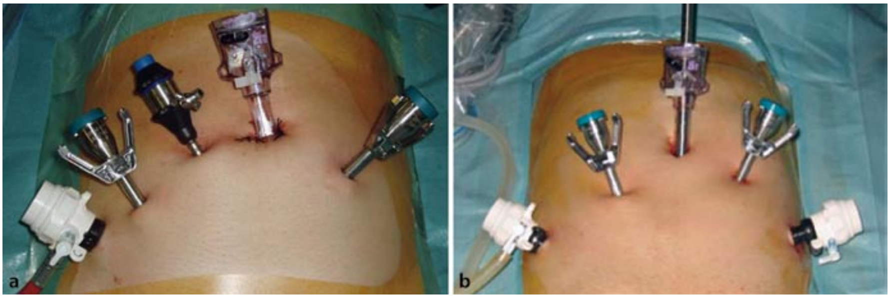

Fig. 3.7 Trocar positions in a 3-arm-system. Position of the trocars with one assistant (**a**) and two assistants (**b**). Routinely, the procedure is performed with one assistant. Small pelvic anatomy may require two assistants

burg position, compared with the transperitoneal access, is only about 15°. This improves intraoperative ventilation and prevents conjunctival edema. In addition, the robot arms are more easily connected with minimal Trendelenburg.

3.3.2 Trocar Placement

The trocar placement in robotic and laparoscopic urology is of major importance. In extraperitoneal radical robotic prostatectomy, the robot trocars are placed 1–2 cm below the infraumbilical camera access (Fig. 3.6). The best exposure of the left rectus layer is achieved by blunt finger dilation slightly off-midline, followed by the balloon device (Figs. 3.2, 3.3). The additional enlargement of the working space by the camera, sweeping the peritoneal borders upwards and laterally, is a prerequisite to place the robot and assistant trocars under visual control (Fig. 3.4). A pneumoperitoneum can occur due to a peritoneal fenestration, which is corrected by placing a draining cannula in the upper left quadrant. Median time from first incision until beginning the console work is in the standardized setting about 15 min. The close vicinity of the robotic and assistant instruments can create some conflicts [10], which may be overcome easily by minimal lateral displacement of the robotic trocar (Table 3.1). The extraperitoneal space is large enough, even to work with a fourth arm [11]. In patients with a very small pelvis, the use of bilateral assistant trocars is recommended (Fig. 3.7; Table 3.1).

3.3.3 Operative Time

The extraperitoneal technique may have the shorter learning curve compared with the transperitoneal access [12, 13]. The retrovesical dissection in the Douglas space is not necessary (if this initial step is performed) and, in any case, the extraperitonealization of the bladder is omitted.

While the initial placement of the trocars may take some minutes more, total operative time is shorter than in the transperitoneal approach [5, 14–19]. It was found that the elimination of the bladder dissection (retrovesical dissection and bladder

Table 3.1 Pitfalls and tricks in extraperitoneal approach

Problem	Solution
Peritoneal leak	Drain with cannula
Extraperitoneal dilation impossible	Change to transperitoneal access
Very small pelvis	Bilateral assistant trocar position (see Fig. 3.7)
Interference robotic/conventional instruments	Transpose robotic trocar 1–2 cm
Tension on anastomosis	Reduce C02 pressure (aspirator), use clamp for bladder wall
Uni- or bilateral mesh implant	Transperitoneal access
Kidney transplant	Transperitoneal access
Extended pelvic lymphadenectomy	Transperitoneal access

Table 3.2 Benefits of the extraperitoneoscopic approach

Shorter operative time [5, 14–18]
Better ventilation due to reduced Trendelenburg position
Improved dexterity [25]
Open dissection planes after previous intraperitoneal surgery [23]
Better working space in obese patients [23]
Less subileus, return to full diet earlier [5, 22]
Less abdominal pain [5, 14]

extraperitonealization) shortened the procedure by 50 min [5]. The absence of intraperitoneal organs, i.e., small intestinal loops, facilitates and accelerates the dissection and the change of instruments.

3.3.4 Avoiding the Intraperitoneal Cavity

There is no consensus as to which approach generally should be used [20, 21]. Definitively, there are patients in whom an extraperitoneal approach is favorable. Previous extensive pelvic surgery or inflammations with adhesions and fixed intestinal slings in the pelvis might complicate a transperitoneal surgery. Using the extraperitoneal approach, the risk of bowel injury is very low and postoperative ileus and peritonitis are very rare (Table 3.2). With the extraperitoneal approach, less subileus and earlier return to full diet [5, 22] was found, combined with less abdominal pain [5, 14]. The extraperitoneal approach may be superior in patients with gross obesity (Table 2) [23]. In cases of a pelvic kidney, the extraperitoneal approach is feasible [24]. Patients after renal transplantation (Table 3.1) require a high trocar placement, and therefore a transperitoneal approach is recommended. Finally, transperitoneal access is recom-

mended in cases with extended pelvic lymph node dissection in order to avoid postoperative lymphocele formation (Table 3.1) and in patients in whom the extraperitoneal space is closed due to prior laparoscopic hernia repair with mesh implants.

3.4 Conclusion

Although the transperitoneal access is still favored by the majority of the robotic teams, the extraperitoneal access finds growing popularity. While oncological and functional outcome is similar in both techniques, the extraperitoneal approach, avoiding the intraabdominal cavity, has some distinct benefits. However, special circumstances require either a transperitoneal or extraperitoneal technique; therefore, centers of robotic expertise should train in the parallel use of both approaches.

Acknowledgement. I thank K. Horton for his review of this chapter.

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Chapter

Robotic Radical Prostatectomy: Transperitoneal Access

4

Charles-Henry Rochat
and Jean Sauvain

4.1 Introduction

We found the mini-invasive approach for prostate cancer interesting and promising immediately after the first reports on its feasibility. While experience was still limited in Europe, we performed the first laparoscopic prostatectomies in Switzerland in March 1999. At this time, we used the trans-abdominal access as described by the team of Moutsouris in Paris [1]: opening of the peritoneum into the Douglas pouch to start with the dissection of the seminal vesicles, and then a second incision, in an inverted U shape from the deep inguinal orifice to the other, to lower the bladder and gain access to the anterior face of the prostate; then, dissection of the prostate from the bladder neck to the apex in an antegrade manner.

For patients with a history of heavy abdominal surgery and also due to our interest in reproducing the surgical protocol of the classic retropubic prostatectomy, we have also become accustomed to performing the retrograde extraperitoneal laparoscopic prostatectomy (PERL) developed by P. Dubernard [2, 3].

Presently, there is no consensus on what is the best access to the prostate and the choice still depends on the operating team's experience. There are partisans of the transabdominal access, and partisans of the pure extraperitoneal access. The same discussion appears for the dissection of the prostate, which can be either retrograde or antegrade. Only primary dissection of the seminal vesicles seems to have been unanimously abandoned.

While the number of teams performing laparoscopic prostatectomies in the early 2000 increased exponentially, the robot Da Vinci went on the market. Rapidly this technology revealed its advantages in small-space surgery, such as prostate dissection.

J. Binder performed the first laparoscopic prostatectomy in May 2000, using the Da Vinci robot.

The robot offers a real surgical alternative compared with the long and difficult learning curve of the conventional laparoscopic prostatectomy [4]. We were rapidly persuaded that the improvement in precision and vision will allow accomplishment of high-quality prostatectomies, and that this system represents the natural evolution of the conventional laparoscopy by ameliorating the performances of the experienced laparoscopic surgeons [5–7].

Fig. 4.1 Da Vinci S enhances mobility and fluidity of the arms

The particularity of the Da Vinci radical prostatectomy is that we have to face the problem of small anatomical space and possible conflicts between the arms of the robotic system, which require certain adjustments of the surgical protocol of the conventional laparoscopic prostatectomy [8, 9]: the Lloyd Davies position instead of the dorsal decubitus to allow positioning of the robot between the legs; with no placement of suprapubic trocar because of the lack of access due to the robot arms (the new S system gives more space for the assistant (Fig. 4.1)), the assistant can use two working trocars as the camera is held by the robot. With the four-arm system the prostate can be reclined from a trocar inserted laterally into the left fossa iliac.

4.2 Steps of the Transperitoneal Access

4.2.1 Preparation

The laparoscopic prostatectomy does not require a different preoperative preparation compared with a standard abdominal operation (see Table 4.1). The antiplatelet therapy should discontinue 10 days before the intervention and heparin the day before surgery; however, this is the decision of the surgeon or the anesthetist. A rectal enema is performed in the hours preceding the intervention to ensure the vacuity of

Table 4.1 Steps of the transperitoneal access

Lloyd Davies position, Trendelenburg up to 30°
Peri- or supraumbilical incision to insert the trocar for the optics
Insertion under vision control of five others trocars (three for the robot and two for the assistant if four-arm system)
Anterior peritoneum incision and primary lowering/extraperitonealizing of the bladder
Exposure of the anterior face of the prostate and internal face of the obturator fossa

the rectum. It is noted that at the level of the planning of the intervention, we wait 6 weeks after the diagnostic biopsies so that the periprostatic inflammatory reactions are resorbed.

4.2.2 Installation of the Patient

We use general anesthesia without associated epidural anesthesia. The patient is in Lloyd Davies position, with the legs lowered and Trendelenburg up to 30°. The arms are placed alongside the body (Fig. 4.2).

A Ch 16 silicon urinary catheter is placed. Through a subumbilical incision (under-umbilical for the brevilignes) a Veress needle is inserted (or an open laparoscopy is performed if there is a risk of periumbilical adherences), followed by insufflation up to 16 mmHg and installation of one 12-mm trocar for the optical instruments (Endopath bladeless XCEL, Ethicon, Norderstedt, Germany) and introduction of the 30° of the system Da Vinci and examination of the abdominal cavity. Using a marker one can locate the incisions of the additional trocar.

A V starting at the root of the penis helps to locate the position of the two 8-mm trocars of the robot at 18 cm distance, with a space corresponding to a hand on both sides of the umbilical trocar. A 12-mm VerSastep trocar (Tyco, Norwalk, Conn.) is inserted two fingers inside and two fingers upward of the right anterior iliac crest (Fig. 4.3). Through this trocar one can insert the camera and control the placement of the umbilical trocar and guide the insertion of a 5-mm trocar between the right arm and the optical instrument (Fig. 4.4). On the left side, in the same way, a 5-mm/8-mm trocar (assistant tool or fourth arm of the robot) is inserted. The robot is then connected and the position of the operating table is locked. The umbilical trocar with the camera exerts a discrete rise of the abdominal wall (Fig. 4.5, 4.6). The pressure of insufflation is decreased to 12 mmHg.

4.2.3 Access to the Pelvis and Incision of the Anterior Peritoneum

The optics 30° is directed to the top (up on the console), and the surgeon at the console handles a bipolar forceps on the left arm, and of the monopolar scissors on the right

Fig. 4.2 Patient installation for radical prostatectomy

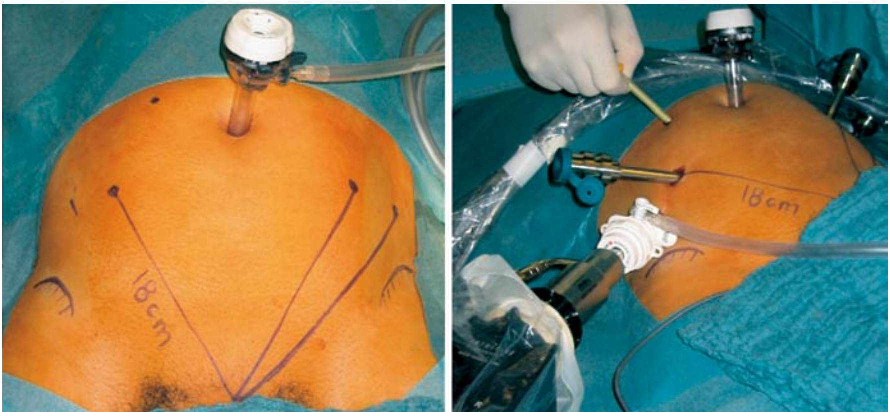

Fig. 4.3 Placement of the trocars

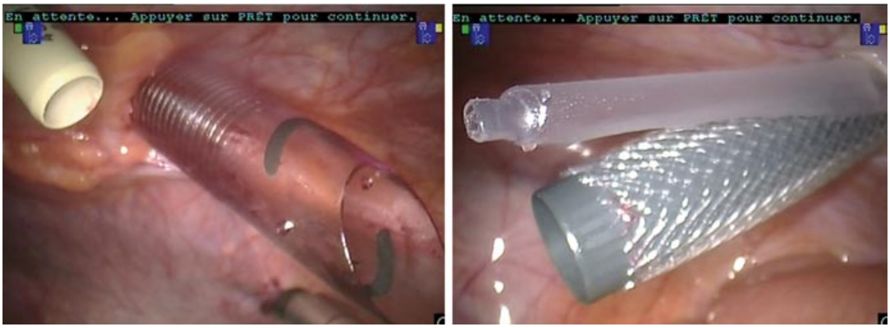

Fig. 4.4 Vision control of the trocars from inside (VerSastep on the right)

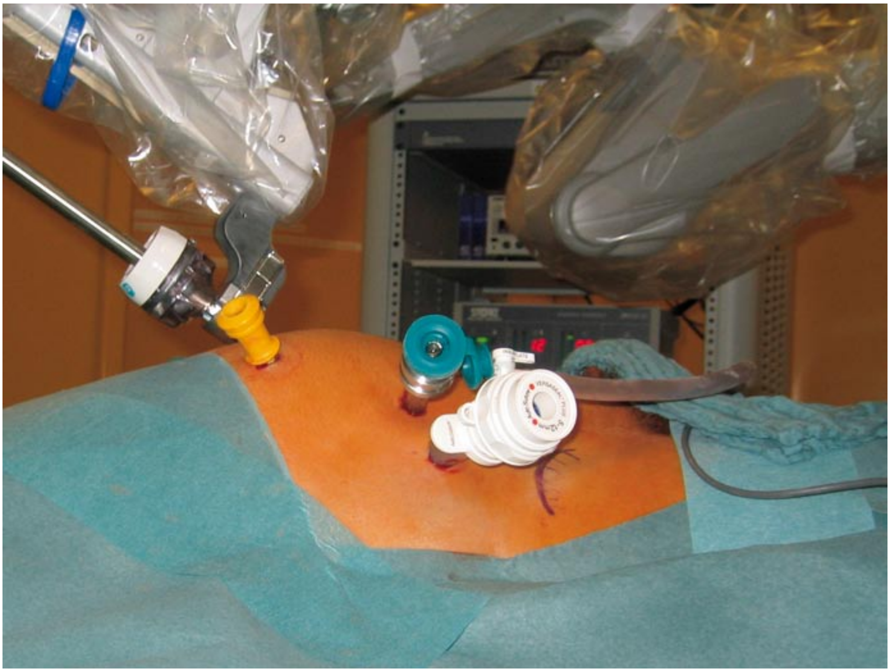

Fig. 4.5 The umbilical arm raises the abdominal wall

arm, and a grasper on the third arm (if available). The electric current is regulated between 20 and 40 W on the bipolar forceps and has 40 W on the monopolar scissors. The assistants hold a Johan forceps and a suction device. The sigmoid loop is released from possible adherences and the small intestine is pulled back upwards (Fig. 4.7). The peritoneum is incised by dividing the umbilical arteries, and while going down to the

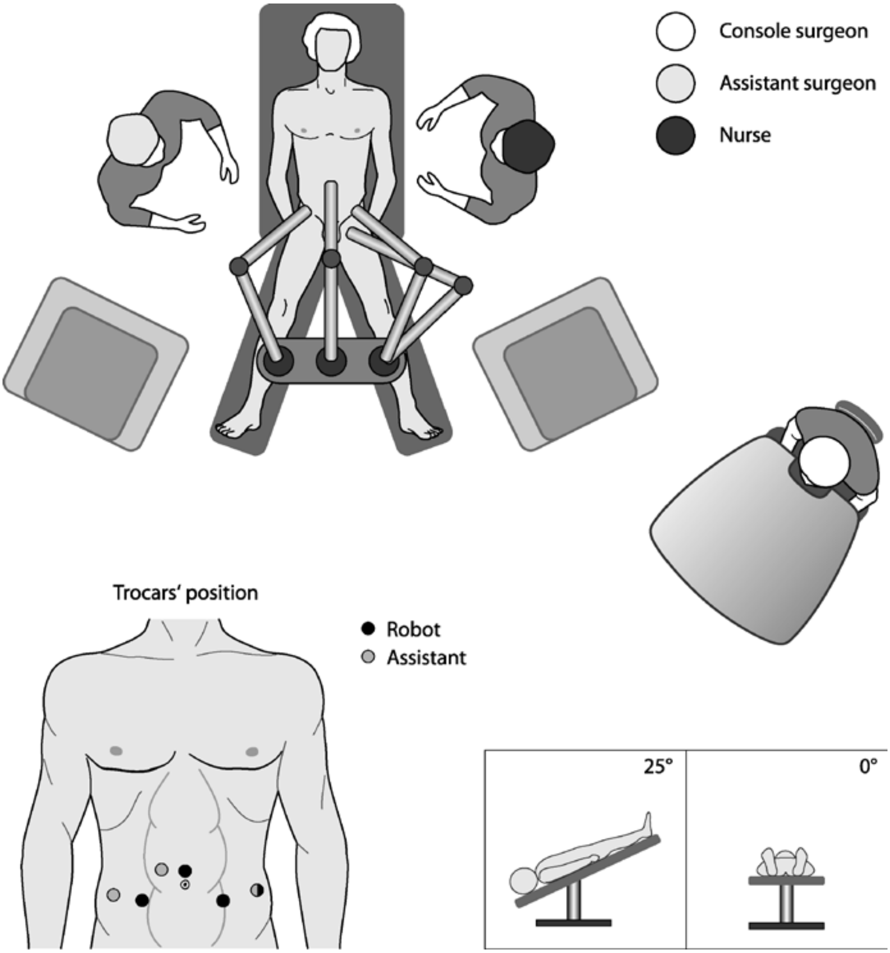

Fig. 4.6 Schematic view of the installation

deep inguinal ring, the vas deferens is retracted or divided to give more mobility to the bladder (Fig. 4.8, 4.9).

The pneumoperitoneum facilitates the dissection of cellulo-fatty space, and the assistant using the suction device contributes to the complete the lowering of the bladder exposing the pubic arc and the Cooper ligament, the internal face of the obturator fossa, and the anterior face of the prostate (Fig. 4.10).

All the fatty tissue covering the prostate, the endopelvic fascia, and the puboprostatic ligaments is removed. The transperitoneal access is then accomplished and the radical prostatectomy can start.

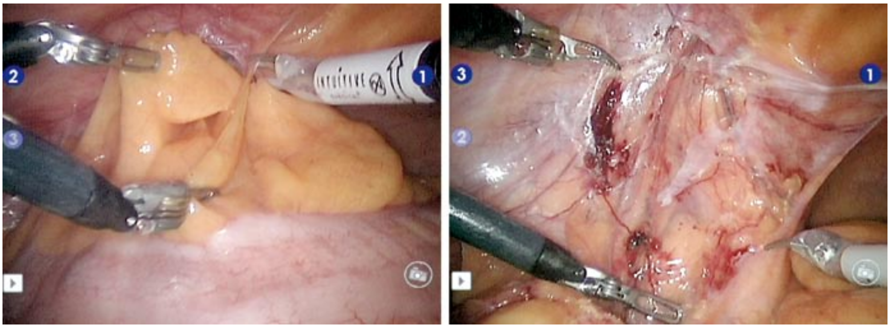

Fig. 4.7 Sigmoid loop mobilization

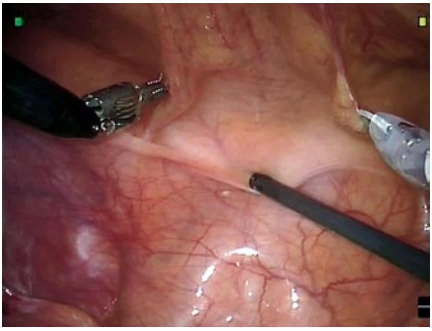

Fig. 4.8 Incision of the anterior peritoneum (view of the umbilical arteries)

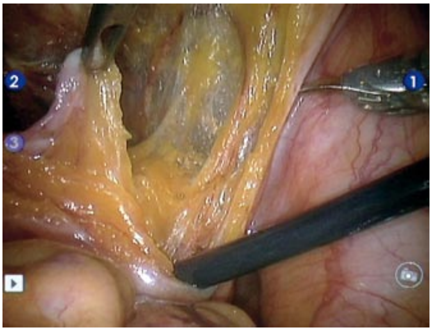

Fig. 4.9 Division of the right vas deferens

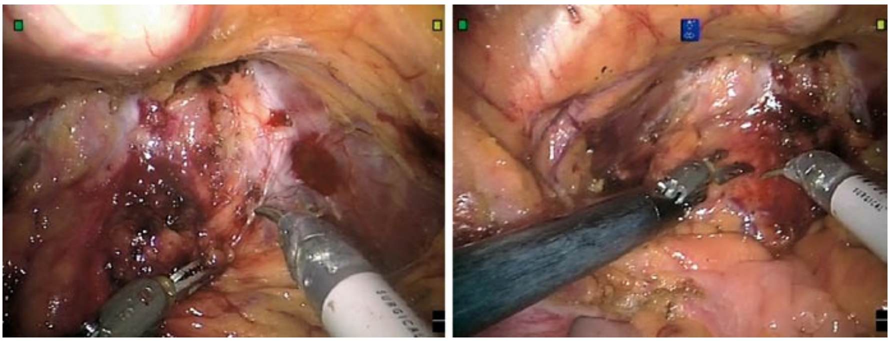

Fig. 4.10 The fatty tissue covering the prostate is removed

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Chapter

5

Pelvic Lymphadenectomy for Localized Prostate Cancer and Robotic-assisted Radical Prostatectomy

Oliver W. Hakenberg
and Manfred P. Wirth

In the era of routine usage of prostate-specific antigen (PSA) for the diagnosis and staging of prostate cancer, the validity of the clinical diagnosis of localized prostate cancer has improved. Large contemporary series of radical prostatectomy (RP) by any surgical method consist mostly of truly localized and node-negative cases; thus, due to the stage-shift following the widespread use of PSA testing, the incidence of positive nodes in patients undergoing RP has declined. Therefore, many groups prefer not to perform pelvic lymphadenectomy in patients with a low likelihood of harboring nodal metastases. However, there are also good arguments for routine pelvic lymphadenectomy.

5.1 Arguments for and Against Routine Pelvic Lymphadenectomy

Essentially, there are good arguments for and against routine pelvic lymphadenectomy in RP for localized prostate cancer in the era of routine PSA- and Gleason score-based staging. The main arguments for pelvic lymphadenectomy are that nodal disease may exist in a small proportion of cases despite adequate staging and that the diagnosis of pN-positivity will allow for better staging (with the view of adjuvant treatment) and may even have potential influence on outcome. The main arguments against routine lymphadenectomy are that it constitutes potential overtreatment in the majority of cases, that it contributes to the morbidity of the procedure (in addition to prolonging surgical time and hence costs), and that any substantial influence on outcome is unproven. These arguments should be examined in detail.

5.2 Morbidity of Pelvic Lymphadenectomy

The main argument against routine pelvic lymphadenectomy is that it considerably contributes to the morbidity of RP. The specific complication of bilateral pelvic lymphadenectomy is lymphocele formation. This risk is reported to amount to only 3–5% in series reporting the clinical frequency of this complication only [18]. The protagonists of routine extended lymphadenectomy claim that the frequency of pelvic lympho-

cele formation in their practice is low (2.7%) due to meticulous surgical technique, with ligation of all lymphatic vessels, double drainage, and injecting prophylactic low molecular weight heparin into the arm, not the thigh [16]; however, counting only lymphoceles which led to prolonged hospitalization or rehospitalization considerably underestimates the true risk of lymphocele formation [31]. This was shown in series reporting all lymphoceles of any size detected by routine use of imaging modalities in all patients [45, 46]. In these series the rate of pelvic lymphoceles of any size – irrespective of whether these were clinically apparent and/or required treatment – was 27–61%. Pelvic lymphoceles can cause further complications by compression and/or inflammation and are associated with an increased risk of deep venous thrombosis [33]. Clearly, lymphocele formation is more common than is apparent clinically and associated with a risk of serious complications. Whether any specific surgical technique – and most centers will certainly have meticulous techniques – reduces the risk of lymphoceles is completely unproven.

In a randomized study of 123 patients undergoing limited PLND on one side vs extended PLND on the other side, an overall complication rate of 10.6% was reported, with 75% of these occurring on the extended side [20]. In contrast, Heidenreich et al. reported no difference in complication rate in a comparison of two cohorts with either limited or extended bilateral PLND (9% in both groups) [32]. For laparoscopic PLND in 372 cases from 8 centers, Kavoussi et al. reported an overall complication rate of 15% for the early years of urological laparoscopy [36]. Although the overall complication rate of PLND seems to have declined similar to that of RP in general [4], undeniably, PLND adds potential morbidity to RP. It is therefore necessary to discuss whether routine PLND should be performed in all patients and to which extent this PLND should be performed.

5.3 Extent of Pelvic Lymphadenectomy

The added morbidity due to pelvic lymphadenectomy and the resulting increase in surgery time (and hence costs) have led to the widespread performance of routine pelvic lymphadenectomy only in patients with significant risk of harboring node metastases and/or of only performing a so-called limited pelvic lymphadenectomy of the obturator field only; however, the extent of lymphadenectomy in RP is not clearly defined. For the purposes of this discussion – and in accordance with the usage of most authors – three forms of lymphadenectomy in RP can be distinguished:

1. PLND limited to the obturator fossa (*limited or standard PLND*: between the external iliac vein, the obturator nerve and the branching off of the internal iliac artery). This is what many surgeons who routinely perform PLND will do for patients with low risk of node-positive disease.
2. *Modified PLND* (obturator fossa plus the lymphatic tissue around the internal iliac artery).
3. An *extended PLND* additionally including the area of the common iliac artery. While protagonists of the routine use of PLND and its potential benefit for outcome usually advocate the second form (modified PLND), the extended variety of PLND (including the common iliac artery) is only advocated by few and has been done for scientific purposes in some studies of RP [32, 48].

The argument against just doing a limited PLND (obturator fossa only) is that it underestimates the true incidence of positive nodal disease since it does not include important sites of frequent primary nodal spread. The frequently cited paper supporting this view is that by Heidenreich et al. who performed extensive PLND (including the common iliac artery regions) in two series of consecutive patients (100 with limited vs 103 with extensive PLND) and removed an average 11 nodes with limited and 28 nodes with extensive PLND, finding 12 vs 26% of pN+ disease in these well-matched cohorts [32]. For laparoscopic RP, Stone et al. reported a higher incidence of nodal metastases detected in laparoscopic RP comparing modified and extended PLND in 189 patients (average nodes removed 9.3 vs 17.8; node-positive rate 7.3 vs 23.1%) [48]. Similar findings were reported by Touijer and Guilloneau (limited vs extended PLND in laparoscopic RP: mean nodal yield 9 vs 14; the relative risk (RR) of node positivity was 21.2 with extended vs limited PLND) [49].

Not all series come to the same conclusion, however. Clark et al. reported a prospective series of 123 patients randomized to a limited PLND on one side vs an extended PLND on the other side (including presacral nodes) [20]. With an overall rate of node-positive disease of 6.5% (mean preoperative PSA 7.4 ng/ml, 72% T1c disease) they found 4 pN+ cases by extended PLND vs 3 cases by limited PLND (and one case with bilateral pN+ disease). They concluded that in contemporary series, extended PLND identifies few additional node-positive cases and should not be advocated. This study has been criticized in that the side of carcinoma in the prostate was not reported and that, as a result, in up to 50% of cases the wrong side might have received extended PLND [16].

5.4 Location of Node-positive Disease and Lymphatic Drainage

The crucial question is that of the anatomical location of primary nodal spread in prostate carcinoma. Proper anatomical studies clarifying this issue do not exist, so this can only be assumed on the basis of clinical studies of lymph node-positive locations. Bader et al. reported the results of modified PLND in 365 consecutive patients (median number of nodes removed 21; pN+ 24%) [7]. Of the 88 node-positive patients, 58% had positive nodes at the internal iliac artery and 19% had positive nodes exclusively in this location; thus, this group strongly advocates routine usage of modified PLND in all patients as a fifth of patients will otherwise be understaged and positive nodes will remain in place in more than half of cases [16]. However, this study with a median preoperative PSA of 11.9 ng/ml and only 50.6% pT2 disease is perhaps not comparable to all contemporary RP series [34].

It is, however, clear that the extent of PLND will determine the number of lymph nodes removed and that with increasing numbers of nodes removed the likelihood of the detection of nodal metastases will increase. In a study of 858 men with extended PLND (median preoperative PSA 5.8 ng/ml, 55% T1c and 40.7% T2) a median of 14 nodes were removed with 10.3% node-positive cases [14]. There was a significant correlation between the number of lymph nodes removed and the rate of lymph node invasion (LNI) diagnosed (2–10 nodes removed: 5.6% LNI; 20–40 nodes removed: 17.6% LNI) and on multivariate analysis, the number of nodes examined predicted for LNI ($p < 0.001$). Further analysis led to the conclusion that the removal of 28 nodes

yielded a 90% ability to detect LNI, whereas the examination of 10 or fewer nodes was associated with a virtually zero probability of detecting lymph node involvement. Allaf et al. [3] reported on the comparison of two large consecutive series of RPs with PLND performed at the same institution by two different surgeons ($n = 2135$ vs 1865) between 1992 and 2003. One surgeon always performed an extended PLND while the other always did a limited one. In this comparison, extended PLND yielded more nodes (mean 11.6 vs 8.9, $p < 0.0001$) and detected more lymph node-positive disease (3.2 vs 1.1%, $p < 0.0001$) and this finding held true for patients across all pathology groups. In men with pN+ disease involving less than 15% of extracted nodes, the 5-year PSA progression-free survival was 43% in the extended PLND cohort and only 10% in the limited PLND group [3]. The authors concluded that a significant PSA-free survival benefit exists for some subgroups of patients, but that their results might have been influenced by stage migration. Stage migration due to changes in diagnostic possibilities and criteria – in prostate cancer the use of PSA and changed Gleason score classification over decades is known as upgrading – can result in improvements in survival which, however, represent a statistical artifact (the Will Rogers phenomenon) [2, 25].

Thus, it seems clear that limited PLND (obturator fossa) will leave a proportion of affected lymph nodes in place in some patients. There also seems to be individual variability in the route of the first lymphatic spread of prostate cancer. The reason for this presumably is that lymphatic drainage from the prostate follows different pathways from different areas of the prostate and that perhaps varying degrees of prostatic enlargement due to benign hyperplasia will contribute to opening or enlarging pre-existing lymphatic drainage channels. The heterogeneous and often multisited location of prostatic carcinoma will also account for the variable location of the first positive node which may thus be an individual feature of the patient, depending on prostate size and the intraprostatic location of the carcinoma.

Following these considerations and in an attempt to limit PLND and its complications, the concept of sentinel lymph node detection using lymphoscintigraphy and radio-guided surgery whereby on an individualized basis only radiopositive nodes are removed was developed for prostate cancer [52]. The overall detection rate of metastatic nodes with this technique was 19.6% in 1055 patients [53], greater than predicted with current nomograms, and 63% of positive nodes detected were outside the area of the standard limited PLND. Similarly, Jeschke et al. reported 73% of node-positive disease detected by radio-guided sentinel node surgery outside the obturator fossa [35]. This concept of an individualized lymph node search has been confirmed to have a sensitivity of positive node detection of >90% [26]. Refinements of this approach to PLND by the combination with modern imaging techniques are possible [51] and the technique has been developed for laparoscopic RP [35]; however, for most groups radio-guided sentinel node PLND will significantly increase operating time and costs.

5.5 Purpose of Lymphadenectomy

The controversy is further increased by differing views on the impact of the removal of pelvic nodes potentially harboring nodal metastases. Pelvic lymphadenectomy is traditionally considered purely a staging procedure detecting lymphatic spread and identifying patients who will need postoperative adjuvant treatment. Protagonists of routine lymphadenectomy including areas outside the prostatic fossa argue that there

is a possibility that a properly executed PLND (at least modified) which removes an early and limited nodal spread may also have an impact on the disease course, i.e., might have curative potential [16]; however, those in favor of limiting pelvic lymphadenectomy to a standard (obturator) field or not doing it at all argue that nodal spread irrespective of whether it is micometastatic or minimal does signify systemic disease and will not allow for surgical curation of the disease [34].

Following the argument that PLND is a staging procedure, antagonists of routine usage of PLND argue that if pN+ is detected (i.e., systemic disease is diagnosed), RP should consequently be aborted [34]. This, however, is not the current practice of most groups when encountering minimal or microscopic lymph node disease. The usage of aborting RP after frozen-section examination of removed lymph nodes is historical in view of the stage migration with a decline in positive lymph node findings at PLND. Also, the false–negative rate of frozen section for micrometastatic disease can be as high as 30% [24]. Furthermore, some groups advocate performing RP in locally advanced disease (pT3) given the only marginally reduced survival rates compared with pT2 disease and the reduced local complication rate with disease progression [50, 54].

What is the evidence? Cheng et al. analyzed the volume of lymph node metastasis in 269 node-positive RP patients and reported it to be a significant predictor of systemic progression in addition to the primary predictors of Gleason score, cancer volume, and DNA ploidy [19]. Daneshmand et al. reported on the prognosis of 235 node-positive RP patients (12.1% from a cohort of 1936 men with a median follow-up of 11 years) and found a significantly higher relative risk of clinical recurrence depending on the lymph node density [22].

5.6 Influence of Lymphadenectomy on Outcome in RP

In 2003, Bader et al. analyzed the progression rate of 367 RP patients with 25% having positive lymph nodes [8]. With a median follow-up of 88 of the node-positive patients of 45 months, they reported 22% deaths from prostate cancer (only in patients with more than one positive node). No disease progression was seen in 39% (15 of 39) of those with only one positive node, in 10% (2 of 20) of those with two positive nodes, and in 14% (4 of 29) of those with more than two positive nodes. These data – an update of which has not been published thus far – form the basis for the group's claim that meticulous lymph node dissection may have a positive impact on disease progression and long-term disease-free survival [8]. This position is supported by the already discussed findings of the Johns Hopkins group of prolonged 5-year PSA recurrence-free survival in extended vs limited PLND [3]. Already in 1987, Golimbu and colleagues had reported on good overall survival in patients with only one involved lymph node after RP with PLND [27].

The claim that meticulous PLND can improve survival is, however, contested by many authors. The Cleveland Clinic group retrospectively analyzed the biochemical failure rates in 336 low-risk RP patients of whom 140 had undergone PLND and 196 had not (mean follow-up 60 months) and found no significant difference in biochemical recurrence rate (14 vs 12%) [11]. Recently, the same group reported results of a retrospective CaPSURE analysis of 4693 RP cases with and without limited PLND [10]. Stratification of patients into risk groups in this analysis showed no overall influence of PLND vs no PLND on biochemical recurrence-free rates nor in the groups of

low, intermediate, or high risk. They concluded that patients with low-risk characteristics can be spared the additional risks of PLND. The Mayo Clinic group reviewed the 7036 cases from their database and reported a significant decrease in the median number of lymph nodes removed at PLND with RP over the years (mean of 14 from 1987 to 1989 to 5 from 1999 to 2000). With a median follow-up of 5.9 years they found no significant association between the number of lymph nodes removed and PSA progression [23]. Finally, the Memorial Sloan-Kettering Cancer Center group anlayzed their database of 5038 consecutive RP patients who had an average of nine lymph nodes removed at RP (3.8% positive) [37]. They found a significantly higher hazard ratio for biochemical recurrence (5.2, $p < 0.0005$) in lymph node-positive cases. While the number of nodes removed in node-positive cases did not correlate with freedom from biochemical recurrence, it did so in patients with negative nodes.

The case is difficult to prove. The RP by any method in clinically localized cases results in high overall survival which is dependent on surgical stage, surgical margins, specimen Gleason score, and the presence of metastatic disease; however, the presence of nodal disease alone does not determine overall survival. Furthermore, prostate cancer with its slow progression does not allow for short-term conclusions, and studies have to mature over at least 10 years until meaningful calculations of survival can be made.

While the surrogate survival parameter of PSA progression is used, its correlation with overall survival confounded by comorbidity in the typical prostate cancer age group is limited. Most adjuvant therapeutic interventions after RP, if effective, have shown a significant influence on the biochemical freedom of recurrence rate but fail to improve overall survival. This remains the dilemma of prostate cancer treatment with the long time intervals from PSA recurrence post-RP to hormonal treatment and eventual disease-specific death if it occurs; however, it seems that at present there is no real evidence that PLND in prostate cancer improves overall survival, but that there are indications with conflicting evidence from retrospective studies that it prolongs biochemical-free survival.

5.7 The Likelihood of Nodal Disease Based on the Use of Nomograms

Many groups rely on nomograms to predict the likelihood of organ-confined disease and the presence of lymph node metastases. This approach is based on the retrospective statistical analysis of large cohorts of RP patients. According to the statistical predictions derived from such nomograms, patients can be counseled and treatment decisions can be made.

A wide variety of nomograms, algorithms, and artificial neuronal networks have been constructed to use a given set of input parameters for the prediction of pathological stage and lymph node status in prostate cancer patients. The construction of these statistical instruments is based on retrospective series and only a few have been validated in different patient populations [12, 21, 30].

The classical nomogram of Partin and coworkers [40–42] predicts clinical stage and lymph node status based on the standard limited (obturator fossa) PLND used in the original cohort. The predictive factors are preoperative PSA, biopsy Gleason score, and clinical stage. The Partin tables have been validated and updated including a 1997

study with 4133 patients [40]. In this validation cohort, the Partin tables accurately predicted nodal metastases in 83% of patients. According to the Partin tables for patients with a Gleason score of <7 and a PSA <10 ng/ml the likelihood of lymph node metastasis is 0–3%.

Another nomogram using essentially the same statistical approach has recently been constructed to specifically predict lymph node status based on the same preoperative predictors in 7014 patients from seven institutions [17]. They concluded that it is appropriate to omit PLND when the predicted probability of lymph node involvement is less than 3%. With their nomogram, using the 3% probability cut-off for the indication to perform PLND, 67% of patients would have been spared PLND, with a false–negative rate of 1.5%. Interestingly, the rate of lymph node metastases between the participating institutions in this study ranged from 1.5 to 7%. Including institution as an additional variable in the analysis changed the probability of lymph node metastasis generated by the nomogram [17].

Work showing the relationship between the number of nodes removed and the likelihood of detecting lymph node involvement have led to the realization that the factor of the extent of PLND should be taken into account. Briganti et al. validated a nomogram based on 781 consecutive RP patients (median number of nodes removed 14; pN+ rate 9.1%) [13]. With the exception of PSA all other known predictors (biopsy Gleason score, clinical stage) and the number of nodes removed were accurate predictors of lymph node involvement; however, the model including the number of nodes removed was only slightly more accurate (1.8%) than the model without this predictor.

The use of nomograms is, in any case, not a diagnostic procedure. Nomograms predict likelihoods and do not make a definite diagnostic statement about an individual patient. The predictions of any given nomogram will depend on the original cohorts of patients from which they were derived and validated. The accuracy of prediction is also limited: the Briganti nomogram predicts lymph node involvement with a 78% accuracy, the Partin tables with 83% only. It must therefore be kept in mind that nomograms predict likelihoods of lymph node involvement without certainty of this prediction. For an individual patient, this prediction may be incorrect.

It must also be kept in mind that nomograms are rarely based on an extended PLND; therefore, nomograms are likely to underestimate the true incidence of lymph node disease in localized prostate cancer [15].

There is also no clear cut-off of likely lymph node involvement which is universally agreed on as constituting a "low risk" allowing for the omission of PLND. Should this be 3% as suggested by many or should it be lower? This essentially should be a point of discussion between patient and urologist. Given the low rate of added morbidity with contemporary PLND many patients will opt for more certainty for peace of mind's sake.

5.8 PLND or no PLND?

Clearly different groups arrive at different solutions to this problem. The point seems to be that the mix of cases undergoing RP differs widely between different institutions and countries [17]. If up to 25% of patients are likely to have lymph node involvement [15], an extended PLND seems advisable. If the rate of lymph node involvement is

only 3.7% [17], it is a different matter; therefore, not only nomograms, but also one's own center's data, should be taken into account when making policy decisions about the standardized use of PLND. Nomograms do come into it but will not tell all for an individual patient; however, risk stratification is advisable. For the low-risk group (PSA <10 ng/ml and Gleason score <7) consensus seems to be that routine PLND is not required [4, 16, 34]. For intermediate-risk and high-risk patients, PLND seems required. The debate as to whether this should be a limited sampling PLND or an extended PLND will continue for some time due to the lack of prospective studies. There is no clear evidence at present that PLND improves biochemical recurrence-free survival and there is certainly no evidence that it improves overall survival. Perhaps that would indeed be too much to ask for.

5.9 Pelvic Lymphadenectomy in Conventional Laparoscopic and Robot-assisted Radical Prostatectomy

Less invasive approaches to RP than open surgery have long been shown to allow for a feasible pelvic lymphadenectomy with RP; however, the procedure undertaken with laparoscopic (LRP) or robot-assisted RP (RARP) has usually been a limited (obturator field) lymphadenectomy. This has been shown to increase operative time, but not complications, significantly [9, 28]. Comparing the effects of PLND in RARP (40 patients with vs 105 patients without PLND) Atug et al. reported as the only significant difference between the two groups an increase of surgical time of 9.3% with PLND without significant cost or complication differences [5].

Comparing patients with and without PLND between the transperitoneal and the extraperitoneal approach for RARP, the same group found a non-significant increase in surgical time for the transperitoneal approach but otherwise no differences (performing only 26 PLNDs/80 RARPs) [6].

5.10 Use of PLND in Robot-assisted Radical Prostatectomy

The problem with PLND in both RARP and LRP is that most groups specializing in these techniques do not perform routine PLND at all. Most series of RARP are from hospitals in the United States and these groups will only perform routine PLND "if necessary" [39]. The Vattikuti group considers PLND indicated only if serum PSA is >10 ng/ml, biopsy Gleason score is >6, or more than 50% of biopsy cores are positive [38]. In the first large series reported by this group ($n=250$) based on these criteria PLND was performed in 40% of patients only. Subsequent reports from this group do not indicate that this approach to PLND has been changed.

For LRP, the Montsouris group reported a PLND rate of 22%, Stolzenburg et al. of 38% and the Heilbronn group of 83% (limited PLND, pN+ rate 1.2%) [29, 44, 47]. The feasibility and extent of laparoscopic PLND without significant increase in complications has been reported [55].

In fact, most studies on the outcome of RARP do not even specify the number of patients undergoing PLND [1, 39], and from these publications it seems that the majority of patients – representing a highly selected group of mostly T1c cases – do not

undergo PLND. This seems at least debatable in view of the fact that high percentages of pT3 disease are reported in the same series (25–37.5%) [1, 39].

The fact that nodal yield is an important issue and correlates with pN+ status has thus far only been acknowledged by a few laparoscopic prostatic surgeons [49], whereas the issue of PLND is not even discussed in reviews of LRP outcomes by others [43]. For RARP it seems that the issue has thus far not been taken up at all.

Besides the critical oncological issue of whether or not to perform PLND and to what extent, comparisons of the different techniques of RP looking at surgical time mostly fail to take into account that most LRP and RARP procedures are undertaken without PLND.

5.11 Technique of PLND in Robotic Radical Prostatectomy

By necessity, PLND in robotic RP will, in the majority of cases, be confined to the standard, i.e., limited PLND involving the obturator fossa tissue only. More extensive PLND with the robotic technique is possible but requires extensive additional dissection and considerably prolongs operative time. With the extraperitoneal approach to robotic RP, more than standard PLND is hardly feasible. As most centers will at present only perform robotic RP on highly selected patients with high probability of truly localized prostate cancer, performing the standard PLND for staging purposes is adequate. As previously discussed, the disputed issue for many surgeons is whether to do without any PLND in these patients or not.

Performing a limited PLND with the robot-assisted technique offers no major problems and does not differ from the operative surgical technique employed at open RP [38]. The thin adventitial tissue over the common iliac vein is incised longitudinally and dissected off the vein distally to the pelvic bone and proximally to the region of the internal iliac artery. The lymphatic tissue is grasped and bluntly dissected off the psoas muscle. The obturator nerve is identified by blunt dissection and the package of lymphatic and fatty tissue is freed en bloc from the area of the internal iliac artery proximally to the entrance of the obturator nerve and vessels into Alcock's canal. Both distally and proximally the lymphatic tissue is clipped and transected. Care must be taken not to disturb the tissues overlying and surrounding the external iliac artery as these

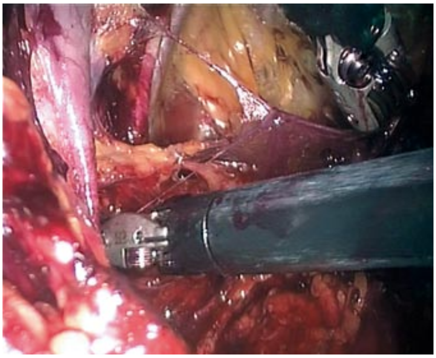

Fig. 5.1 Adipose and lymphatic tissue is bluntly dissected off the common iliac vein on the left side in robotic extraperitoneal radical prostatectomy. In the background the obturator nerve and vessels come into view

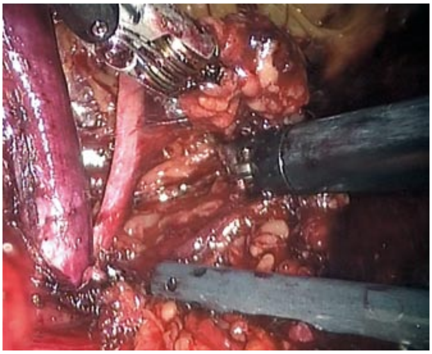

Fig. 5.2 Further blunt dissection to free the PLND specimen from the obturator nerve and vessels (*left side*)

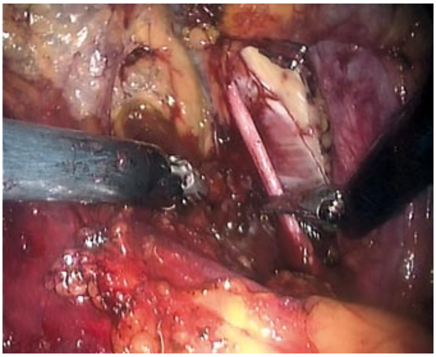

Fig. 5.3 Robotic PLND on the right side: the specimen has been removed, the obturator nerve is clearly visible, and laterally the psoas muscle fibers of the pelvic wall come into view

contain the lymphatic vessels that drain the leg. Disruption of these lymphatic vessels carries the risk of lymphedema of the lower extremities and lymphocele formation.

Extension of the lymphatic dissection proximally can easily be performed to include removal of the lymphatic tissue around the internal iliac artery (modified PLND). It may be advantageous to use a 30° lens for this part instead of a 0° lens as for minimal (obturator) PLND only [38]; however, more extensive lymph node dissection requires considerably more dissection and is more time-consuming with RARP than by the open approach. The use of sentinel-guided individualized PLND has not been reported with RARP thus far.

This standard PLND is easy to perform at the beginning of extraperitoneal robotic RP and should not take more than 10–15 min for each side. With transperitoneal robotic RP, more extensive dissection is required. Firstly, the peritoneum over the common iliac vessels must be incised and dissected off these vessels before the lymphatic tissue below and medial to the common iliac vein can be dissected in standard fashion.

Complications of robotic PLND are bleeding, lymphocele formation, and vascular or neural injury. Bleeding, depending on the source, can usually be controlled by clipping or coagulation. Clipping of lymphatic vessels is of great importance to prevent lymphocele formation. Nerve injury can be prevented and should not occur with proper technique.

5.12 Conclusion

Historically, PLND was a pure staging procedure and RP was aborted in cases of positive findings. This is no longer the case. Evidence from retrospective studies suggests that PLND in cases with low lymph node tumor burden prolongs PSA recurrence free survival and that curative effects may occur in subgroups of patients.

The prediction of the risk of lymph node metastases based on nomograms is not entirely reliable as most nomograms are based on cohorts with limited PLND and will underestimate the true risk of lymph node metastasis. Nomograms cannot, in any case, "diagnose" the risk in an individual patient.

The diagnosis of lymph node disease depends on the number of lymph nodes removed, and modified PLND therefore offers more diagnostic accuracy than limited PLND. The undeniable morbidity of PLND is low in contemporary series. Limited and modified PLND are feasible in open, laparoscopic, and robot-assisted RP, but they increase surgical time. Most authors agree that PLND is probably not necessary in "low risk" patients – PSA <10 ng/ml and Gleason score <7 [4, 16, 34]. This assumption, however, is based on nomograms derived from series of limited PLND. The risk cut-off is not defined and must be discussed with the patient.

In robot-assisted RP the majority of patients are highly selected "low-risk" cases and at present do not undergo PLND. This may, in the long run, be a dangerous policy as it may compromise survival in some patients; thus, a standard limited PLND in all patients undergoing RP is advisable and should be performed in robotic RP as well.

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Chapter

Bladder Neck Dissection During Robotic-assisted Laparoscopic Radical Prostatectomy

6

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6.1 Introduction

The approach to the bladder neck (BN) is the first critical step of antegrade laparoscopic radical prostatectomy. Its identification can be difficult in some cases and a mistake at this point of the surgery can compromise the rest of the operation, influencing the next steps of dissection as well as the anastomosis.

Because of the complexity of the continence mechanism, the value of preserving the BN during radical prostatectomy is still debated, even if there is some evidence for an earlier return to continence in the cases where it is preserved [1]. Preservation of the BN does not seem to be correlated with a higher risk of positive margins [2–3], even if some authors suggest that a wide resection of the BN decreases the positive surgical margin rate [4]. In our opinion, an accurate dissection of the BN and its preservation, especially of the posterior wall, could improve the early return to continence.

The preservation of the BN is not always possible during laparoscopic radical prostatectomy, particularly when a large median lobe is present, and preservation is never possible in case of a previous TURP in which the BN was destroyed. In suspected clinically advanced disease or in the case of positive biopsies at the base of the prostate, we suggest nonpreservation of the BN.

For all the above-mentioned reasons, we describe different approaches to dissection of the BN for each one of these scenarios.

6.2 Anatomy of the Bladder Neck

The bladder neck is the junction between the urinary bladder and the prostatic urethra and is placed at the distal corner of the trigone. At this level the detrusor muscle is clearly separable into the three layers: inner longitudinal; middle circular; and outer longitudinal layers.

In men, radially oriented inner longitudinal fibers pass through the internal meatus to become continuous with the inner longitudinal layer of smooth muscle in the urethra.

The middle layer forms a circular preprostatic sphincter that is responsible for continence at the level of the bladder neck.

The outer longitudinal fibers are thickest posteriorly at the bladder base. In the midline, they insert into the apex of the trigone and interweave with the smooth muscle of the prostate to provide a strong trigonal backing. Laterally, the fibers from this posterior sheet pass anteriorly and fuse to form a loop around the BN. This loop is thought to participate in continence at the BN. On the lateral and anterior surfaces of the bladder, the longitudinal fibers are not as well developed. Some anterior fibers course forward to join the puboprostatic ligaments [5].

6.3 Anatomical–Surgical Correlations

As explained previously, the BN is composed of three layers of detrusor muscle and has in its luminal part the mucosa which continues together with the inner longitudinal fibres into the prostatic urethra.

On a three-dimensional view we can identify six regions around the BN, like the faces of a cube.

Anterior to the BN is the Retzius space, the endopelvic fascia with the end of the puboprostatic ligaments and the superficial branch of the deep dorsal vein of the penis. Proximally the BN is related to the bladder lumen and the trigone. Laterally and behind the lateral part of the BN, we find the prostatic pedicles and the neurovascular bundles of the prostate as well as the lateral part of the seminal vesicles. Posterior to the BN we find, under the Dennonvillier's fascia, the ducts vasa deferentia and the medial part of the seminal vesicles.

Posterior to the BN was always considered to be the anterior layer of the Denonvillier's fascia, which was considered to be a muscular layer of longitudinal fibres. Recently, Secin et al. reported an anatomical study demonstrating that this layer corresponds to the posterior longitudinal fascia of the detrusor muscle which is externally upholstered by the bladder adventitia [6].

Caudally, the BN has a close relation with the prostate, which in this area does not have a really well-defined capsule; however, at this level with the introduction of laparoscopy, and even more with the robotic approach to radical prostatectomy, we are able to find a real anatomical space in which we can clearly separate the muscular fibers of the bladder neck from the prostatic base. We describe this technique but want to highlight the reality of this anatomy, in which it is possible to find the initial part of the urethral tube, in the initial part of the supraprostatic dissection.

6.3.1 Median Lobe

The normal anatomy can be modified in the case of a large median lobe, where usually the posterior relations are changed. In fact, the presence of a voluminous median lobe pushes the BN cranially, reducing its distance from the ureteral orifices and separating the ducts and the seminal vesicles, which in some cases can be placed far away from the BN, with consequent difficult identification of the right plane of dissection.

This specific situation does not modify the anterior relations of the BN, but it can compromise the right identification of his position during the procedure. For this reason the presence of a median lobe should be well investigated before the surgery with an ultrasound or an MRI.

6.3.2 Previous TURP

In the case of a previous TURP the BN is usually destroyed and modified in is medial portion. In this case the BN can be very close to the ureteric orifices. This modified anatomy should be well considered in order to prevent injury the ureteric orifices during the dissection. It is also important to try and leave sufficient space between the limit of resection and the ureteric orifices to achieve a pristine urethrovesical anastomosis, without risk of injury to one or both ureteric orifices.

6.4 Functional and Oncological Principles of Bladder Neck Preservation

Radical prostatectomy should aim to maintain sexual function, and achieve early continence after surgery, without hindering the final oncological outcome of the procedure.

In previous years a great effort has been put into developing technical refinements in order to improve the clinical outcome and minimize the morbidity of radical prostatectomy. Various mechanisms responsible for male urinary continence have been reported in the literature, but no single definitive conclusion has been reached [7]. The factors favoring continence preservation after radical prostatectomy seem to be: (a) the preservation of pelvic floor structures; (b) external urethral sphincter muscle and the anterior urethral support; and (c) the preservation of the neurovascular bundles. Another important role seems to be the age of the patient. As the patient ages, the elasticity of the pelvic floor muscles appears to diminish and there is limited ability for nerve recruitment [8–13].

Puboprostatic ligaments support the external striated urethral sphincter and their anatomical and morphological stability seems to have an important role in achievement of continence after radical prostatectomy, even if this remains an issue of debate.

Since Young in 1905 first described the role of puboprostatic ligaments in supporting the BN and promoting urinary continence after perineal radical prostatectomy, many authors have quoted the important role of this hypothesis, concluding that the ligaments are part of a larger urethral suspensory mechanism, stabilizing the membraneous urethra to the pubic bone, thereby assuring continence [14, 15].

Other authors have reported a positive correlation between the mean urethral length and the continence rate showing a difference in the maximal urethral closure pressure [16, 17].

Poore et al. examined the effects of puboprostatic ligament and/or BN preservation on urinary continence after radical retropubic prostatectomy and observed an early return to continence with BN preservation but the same final outcomes with a puboprostatic ligament preservation technique or a combination of both [1].

Deliveliotis et al. evaluated three groups of patients in which they preserved the BN, the puboprostatic ligaments, or both, and reported no difference on the final continence rate but an early return to continence in the patients in whom the BN had been preserved [3].

The puboprostatic ligament-sparing technique, as well as the BN-sparing technique, can be discussed also from the point of view of their oncological outcomes. Some authors suggest that sacrificing the puboprostatic ligaments and the BN decreases the apical positive margins [4]; however, this idea is controversial, since other authors have shown no significant differences in positive margin rates between two groups of patients treated with or without puboprostatic ligament-sparing technique [18].

Even if this point is still debatable, if the preservation of the BN does not clearly demonstrate an improvement in the rate of final continence, some studies suggest an earlier recovery of continence, with an obvious improvement in the quality of life, without an increase in the rate of positive margins [1, 3, 18].

6.5 Surgical Technique of Bladder Neck-sparing Dissection During Robotic-assisted Prostatectomy

We describe initially the classical approach and dissection of the BN during a transperitoneal laparoscopic radical prostatectomy assisted by the Robotic Intuitive Surgical System, known as the da Vinci robot, which can provide two or three operative arms. The dissection of the BN could be performed with both systems without substantial differences.

In this chapter we describe the use of the four-arm da Vinci robot, but in the case of the three-arm robot the third arm can easily substituted by the assistant grasp. This can be achieved working with one assistant on the right side of the patient or with two assistants, where the second assistant should be placed on the left side of the patient in the same place as the fourth arm of the robot.

Next we describe port positioning and the use of the fourth arm to illustrate how to use it.

We find it more comfortable using the red arm on the left side to leave enough space for the assistant who is placed on the right side of the patient. The dissection is performed using the yellow arm placed on the right iliac fossa, between the right anterior superior iliac spine (ASIS) and the umbilicus in the middle line or to the proximal third, depending on the position of the assistant ports. With this arm we use the monopolar scissors or the monopolar hook. We suggest to perform the entire procedure with the monopolar scissors on the right arm, to avoid multiple changes of instruments and to reduce the costs.

On the left side of the patient we place the green arm 2 cm laterally to the left rectus muscle and 2 cm cranially to the port for the camera. The red arm is placed as lateral as possible on the anterior left axillary line, three fingers cranially to the left ASIS. The assistant works with two 5-mm ports on the right side (Fig. 6.1).

We always begin with the division of the left colon adhesions in order to better mobilize the bladder once separated from the anterior abdominal wall. This maneuver is performed incising the umbilical arteries as high as possible and continuing the dissection laterally until the vasa deferenti are reached. Is very important to open this

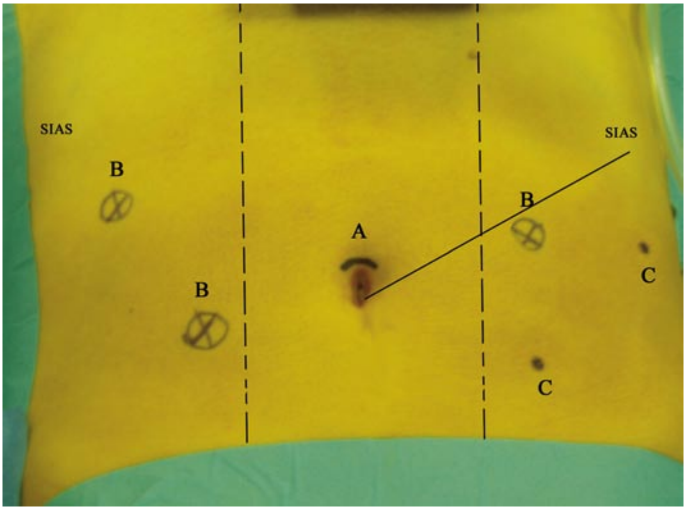

Fig. 6.1 Port positioning. *A* The optical 12-mm port is placed under or above the umbilicus. *B* The three operative 8-mm robotics ports are placed in the middle line between the right superior anterior iliac spine and the umbilicus for the yellow arm, 2 cm cranially to the optical port laterally to the left rectus muscle and three transverse fingers cranially to the left iliac crest at the anterior axillary line. *C* The two ports for the assistant are placed three transverse fingers cranially to the right iliac crest on the anterior axillary line and 3 cm cranially to the camera laterally to the right rectus muscle

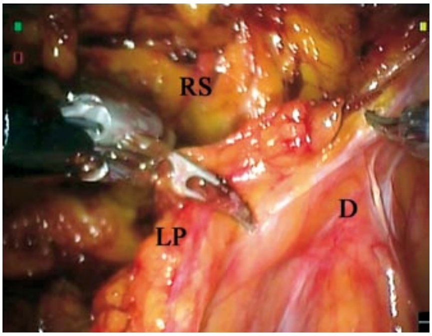

Fig. 6.2 The bladder is separated from the abdominal wall and the peritoneum is opened until the vas deferens is reached as laterally and cranially as possible, to achieve complete mobilization of the bladder. This image is the detail of the right side where the peritoneum is incised until vas deferens is reached. *D* vas deferens, *RS* retius space, *LP* limit of peritoneum incision

space well, incising the peritoneum as cranially as possible to achieve a better mobilization of the bladder (Fig. 6.2).

After the dissection of the Retzius space, the anterior part of the prostate and the endopelvic fascia are liberated from the surrounding fat tissue. During this maneuver which should be continued laterally until the level of the umbilical artery is reached, the superficial branch of the deep dorsal vein of the penis is treated with the bipolar

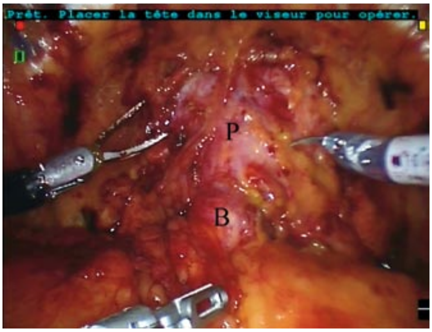

Fig. 6.3 Vision of the prostate (*P*) freed from the fat tissue. The bladder neck and the balloon of the bladder catheter (*B*) are clearly visible

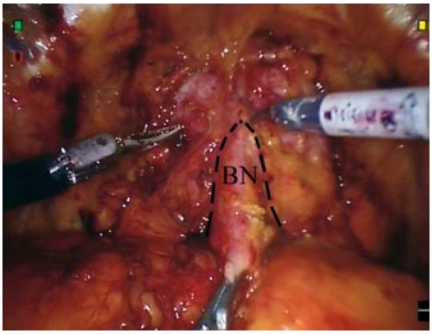

Fig 6.4 The balloon of the bladder catheter is deflated and a moderate traction is performed on the bladder, and the right position of the bladder neck is identifiable. If compared with Fig. 6.3, one can see how the real site of the bladder neck (*BN*) is higher on the prostate base and more caudal of the one identified with the balloon of the bladder catheter

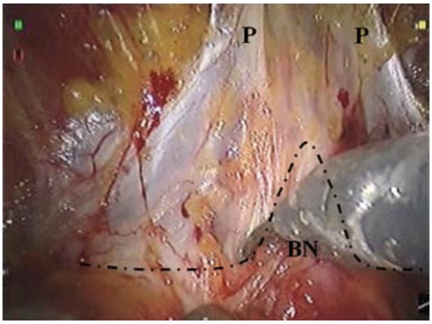

Fig. 6.5 A sharp and blunt dissection of the bladder neck begins at the 10 o'clock position. *P* puboprostatic ligaments, *BN* bladder neck

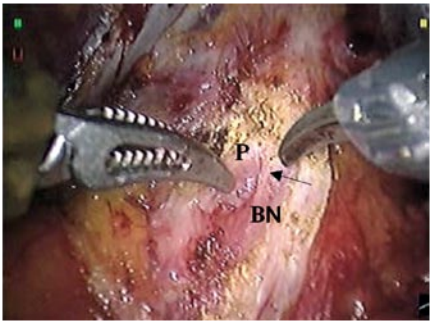

Fig. 6.6 The plane between the prostate base (*P*) and the bladder neck (*B*) is going to be dissected. The muscular fibers are clearly visible (*arrow*)

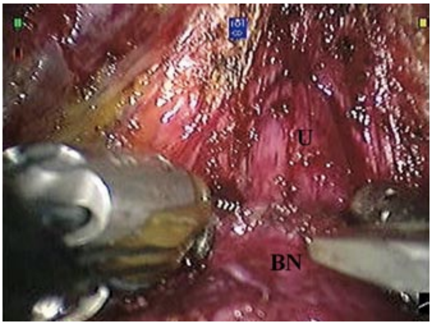

Fig 6.7 The preprostatic urethra (*U*) and the bladder neck (*BN*) are dissected on their anterior planes. The longitudinal fibers of the urethra are clearly visible

cautery and is divided. The puboprostatic ligaments are also freed from the fat tissue and well identified. At this point the vesicoprostatic junction is clearly visible and its lateral margins are free to begin the dissection. If the endopelvic fascia is well prepared, we can identify the prostate, the bladder with the catheter balloon (previously inflated with 4–5 cc of water), and the puboprostatic ligaments reaching the BN (Fig. 6.3).

A little trick to better identify the BN and to begin our dissection in the right place is to follow the puboprostatic ligaments which usually cross at the level of the BN. At this point, the balloon of the bladder catheter can be deflated. Another trick is to follow the deflation of the balloon which can allow better identification of the BN. At this step the fourth arm is introduced. We use a pro-grasp (Johannes) to gently retract the bladder to create a little tension on the BN, in order to better identify it. This maneuver is very important and allows an easier identification of the vesicoprostatic junction, even in situations where there is an evident median lobe. With this we cannot miss our site of dissection (Fig. 6.4).

The aim of the procedure is to find the vesicoprostatic plane that we mentioned in the paragraph covering anatomy. To achieve this step of the surgery it is very important to prepare the endopelvic fascia, the BN, and the anterior surface of the prostate, and to gently retract the bladder with the robotic grasper. We begin a this point, with a combination of blunt and sharp dissection that can be performed as distal as we see the vesical fibers on the anterior prostatic surface or can begin from one side (Fig. 6.5) of the supposed BN in order to move the fibers medially and discover the anterior surface of the prostate (Fig. 6.6). The hemostasis is achieved at this step using the monopolar or the bipolar cautery.

Once the first layers of muscular fibers are dissected from the prostate base, we must follow the plane at 12 o'clock and laterally to the BN at 2 and 10 o'clock, until we clearly identify the inner longitudinal fibers of the BN coming out from the external layer of the outer longitudinal fibers and continuing in what we call "preprostatic urethra" (Fig. 6.7).

When this structure is identified we continue always with blunt and sharp dissection laterally to the urethra with the aim of passing behind the urethra, preserving the proximal urethral sphincter (Figs. 6.8, 6.9). To better achieve this step we can open the space laterally in the direction of the prostatic pedicles as far as necessary to have enough space.

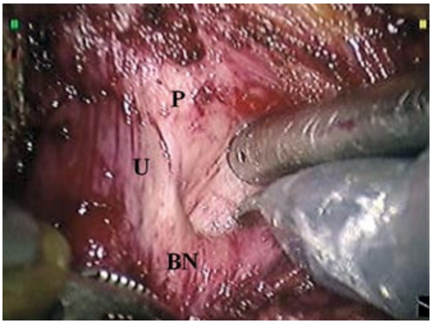

Fig. 6.8 The right lateral margin of the urethra and the bladder neck is dissected from the prostate base. One can clearly identify the prostate (*P*), the bladder neck (*BN*), and the preprostatic urethra (*U*)

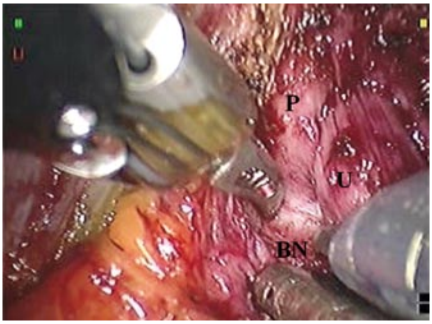

Fig. 6.9 The left lateral margin of the urethra and the bladder neck is dissected from the prostate base. One can clearly identify the prostate base (*P*), the bladder neck (*BN*), and the preprostatic urethra (*U*)

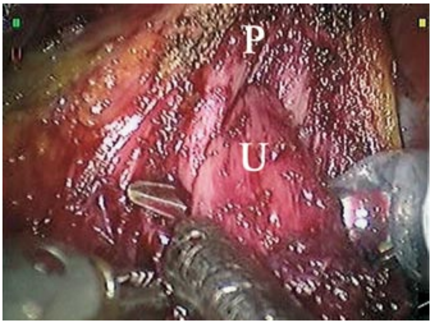

Fig. 6.10 The preprostatic urethra is completely isolated and prepared for transection. *U* preprostatic urethra, *P* prostate base

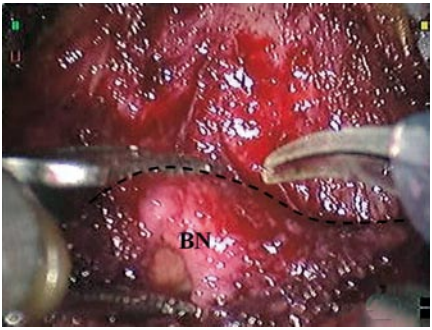

Fig. 6.11 The posterior plane of the bladder neck is going to be dissected from the prostate base. After the division of the "preprostatic urethra," the posterior plane is clearly identifiable (*curve*). The bladder neck (*BN*) is visibly preserved

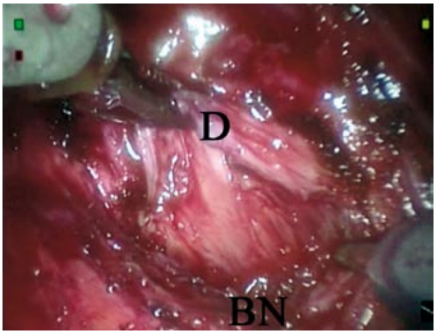

Fig. 6.12 After the posterior plane of the bladder neck is completely dissected, the anterior Denonvillier's fascia (*D*) is identified and incised to dissect the seminal vesicles. In this figure the transected bladder neck (*BN*) is laying down and the bipolar grasp is holding the Denonvillier's fascia to expose it, so that it can be incised

Once the bladder external layer of muscular fibers is completely dissected from the prostatic base all around, the inner longitudinal layer and the preprostatic urethra is clearly visible, coming out from the BN and continuing into the prostate, and we can take out the bladder catheter and transect the urethra (Fig. 6.10).

With this kind of dissection the posterior plane of the BN is at this point partially freed so that in the next step we have to continue the dissection of the same plane in order to reach the anterior layer of the Denonvillier's fascia (Fig. 6.11). We begin the dissection behind the BN and we move laterally until the medial margin of the prostatic pedicles.

Once the Denonvillier's fascia is reached, the bladder should be completely detached from the prostate base apart for the lateral prostatic pedicles, and we are ready for the next step which is the dissection of the seminal vesicles (Fig. 6.12).

6.5.1 Median Lobe

In the previous paragraph we described how to perform the dissection of the BN in a standard case. Now examine the difference in the procedure when an enlarged median lobe is present.

As explained previously, in the case of an enlarged median lobe, we usually find a somewhat different anatomy, with reference to supports from the surrounding structures, especially with the seminal vesicles. With the presence of a median lobe, the site of the BN appears to be more cranial. This can lead to dissection starting at a point too cranial with the risk of opening the bladder on his anterior surface and thus losing the ability to preserve the BN. For this reason, once the endopelvic fascia is well prepared, we should follow the same steps explained elsewhere in this book, to better expose the BN (balloon of the bladder catheter deflating, traction on the bladder). Once the right site is identified, we perform the same sharp and blunt dissection of the anterior fibers from the prostate base searching the plane of dissection between it and the external fibers of the bladder. If we find the right plane, we will be able to identify the preprostatic urethra as described previously. In this case it appears larger than usual because of the presence of the underlying median lobe. Our dissection can now continue in two different ways: with a lateral blunt dissection of the urethral mucosa from the median lobe, delaying its transaction, or with the division of the

anterior portion of the urethra and a delayed dissection of the median lobe from the urethral mucosa. A third kind of dissection is performed without BN preservation and will be described later.

The first approach is performed using a laterally gentle, blunt separation of the preprostatic urethra from the underlying median lobe. After the identification of the preprostatic urethra, we continue its isolation in its lateral portion in order to pass behind it. In this case we will progressively identify the median lobe which prevents this maneuver. Once the median lobe and its limit with the urethra are well identified, we can begin to move the urethra from the median lobe. This is possible, of course, especially with the robot-assisted approach; however, in some cases this will not be possible because of fibrous attachments. Once the urethra is completely freed from the median lobe we can usually pass behind it with our grasp or with the scissors, transect the urethra, and continue our dissection of the posterior plane. In most cases we will have the muscular fibers and the mucosa of the BN preserved, and we will be ready to easily perform the subsequent steps of our prostatectomy.

When the urethra is identified but not easily dissected from the median lobe, we can incise it on its anterior surface before dissecting the posterior plane from the median lobe.

Once the urethra is open, we can dislocate the median lobe outside of the urethra and proceed incising the urethral mucosa on the median lobe. Once the mucosal and the urethral muscular layer are incised, we can perform a dissection of them from the underlying median lobe using again a sharp and blunt dissection.

This maneuver needs to be performed with very gentle dissection because the urethra is usually very thin. The robot allows one to achieve this step, a step which is not always possible with the traditional laparoscopic approach.

Once the urethra is completely dissected on its posterior plane, we should continue our dissection following the muscular fibers carefully, cranially and laterally, in order to not enter into the abdomen, until we are able to find the anterior layer of Denonvillier's fascia and then the vas deferens.

6.5.2 Previous TURP

The dissection of the BN, even in case of previous endoscopic resection, should follow the same initial steps, as previously described, in order to identify the vesicoprostatic junction. Even if we give the same attention in identification of key steps, this can be, in some cases, a real challenge because of the possible presence of fibrous scar tissue. The difference that can be encountered during the dissection will appear when we are getting close to the preprostatic urethra. In its lateral margins the plane of our dissection will become unclear and the tissue will be usually very sticky and with no clear plane. When we reach this point and cannot progress with blunt dissection, it is often not possible to clearly isolate the preprostatic urethra as shown previously. For this reason we usually proceed with sharp dissection and then the incision of the BN at this level initially on its anterior surface. Once the BN is open, we proceed with the identification of the ureteric orifices and we perform a sharp dissection of the posterior margin of the BN, as far as possible from the ureteral orifices, then continuing with sharp and blunt dissection of the posterior plane as described previously.

In some cases, when the BN is preserved during the endoscopic resection and the inflammatory reaction of the previous surgery did not occur, it is possible to isolate a sort of preprostatic urethra that is usually shorter and not as clear as usual. Once it is identified and isolated, it is transected and the dissection proceeds in the same way as described previously.

6.5.3 Wide Resection of the Bladder Neck

In case of positive biopsies on the prostate base, we do not suggest to preserve the BN as described previously, in order to not risk positive margins at this level. In this case we proceed always with the preparation of the endopelvic fascia and with the same steps in order to identify the vesicoprostatic junction. Once its identification is achieved, we use a sharp dissection with monopolar cautery of all the muscular layers of the BN, on its anterior surface first and then, once the BN is opened, we proceed with the incision of its posterior surface and in the dissection of the posterior plane. Our dissection is performed with a safety distance from the prostate base which allows us to avoid any risk of positive margins. Of course, with this dissection we should perform a BN reconstruction before beginning the anastomosis. This is possible without any difficulty using the robot because of its well-known EndoWrist instruments (Intuitive Surgical, Sunnyvale, Calif.). We can perform a posterior BN reconstruction before the anastomosis or we can complete this step on the anterior surface of the BN at the end of our anastomosis. These steps are clearly discussed elsewhere in this book.

6.5.4 Indications and Choice of Technique

It is clearly possible dissect precisely between prostate and bladder, with full preservation of the BN unit. We think that this kind of preservative dissection is extremely relevant for the formation of the future anastomosis, which becomes a "uretro-urethral anastomosis," and the future postoperative continence; however, as reported by some authors, this technique could lead to an increasing rate of positive margins on the primary part of the prostate [4]. Therefore, we reserve this ultra-BN preservation dissection to the cases of localized prostatic cancers, with negative biopsies on the prostatic base, without MRI tumoral localization on the base and without clinical abnormality on the base in digital examination.

In these last situations, we recommend to enlarge the BN dissection in order to let a little part of it get fixed on the prostatic base.

6.6 Bordeaux Series

In our institution (Clinique Saint Augustin, Bordeaux, France) we performed from January 2005 to June 2007, 677 robot-assisted radical prostatectomies. Five different surgeons have performed the same technique of BN preservation, as described in this chapter, in 614 cases (90.6%). In the other 9.4% of patients the BN was not preserved, and these cases included cases which we considered a contraindication: previous

TURP; voluminous median lobe which did not allow preservation; multiple positive biopsies at the base; and cases limited by technical problems of dissection.

In our series we observed 80% of continence (no pads) at 4 months and 91% at 12 months, with less than 1% of anastomotic leakage in immediate postoperative time and less than 2% of anastomotic stenosis.

Our functional results are suggestive of an earlier return to continence, without significantly better results on final continence, in keeping with other series where a BN-sparing technique was used [3].

Concerning the oncological outcome, we observed a positive margin rate on the base of 3% of cases for pT2 disease, and of 5% for pT3 disease. These results are comparable to those reported from some authors in non-sparing BN series [2, 4] as well as series of BN-sparing technique [3].

6.7 Conclusion

The use of robotic assistance gives a fantastic quality of vision and precision of gesture for this difficult step of the radical prostatectomy. It allows a very precise choice of the plane of dissection and a high level of preservation of the BN, which can be adapted to the oncological characteristics and the anatomical specifics of the patient.

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Chapter

7 Nerve-sparing Techniques for Laparoscopic and Robot-assisted Radical Prostatectomy

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7.1 Introduction

The preservation of sexual potency after prostatectomy has always been the topic of much anxiety and debate. While cancer control and urinary continence are of supreme importance, the preservation of sexual function completes the trifecta that both patient and surgeon strive to achieve. Over the decades open nerve-sparing radical prostatectomy has continued to evolve from its early rudimentary beginnings into the more refined techniques that we see at present; however, while we have seen considerable advances in recent times, the limitations in visualization and dissection of the bundle have continued to provide a challenge to even the most experienced surgeon.

The introduction of robotic assistance to modern laparoscopic surgery has provided many advantages, the two greatest being improved three-dimensional magnified vision and wristed instrumentation. These technical enhancements provide the surgeon with improved surgical tools that have the potential to facilitate a more precise surgical approach. One of the potential advantages during robotic prostatectomy is improving visualization, control, and dissection of the neurovascular bundle (NVB). In this chapter we present the pertinent anatomy and the various technical approaches to nerve sparing during robotic radical prostatectomy.

7.2 Neurovascular Anatomy

The pelvic splanchnic nerves provide the autonomic innervation responsible for erectile function. Their origin is in the anterior sacral roots, with most branches originating from S4 and smaller contributions from S2 and S3. These parasympathetic fibers converge with sympathetic fibers from the hypogastric nerve to form the pelvic plexus. The pelvic plexus is rectangular, approximately 4–5 cm long, its midpoint being located at the tips of the seminal vesicles. It is retroperitoneal, fenestrated, and located on the anterolateral wall of the rectum [1].

Cross-connections between the nerve branches of the two sides are formed on the surface of the rectum. The pelvic plexus provides visceral branches that innervate the bladder, ureter, seminal vesicles, prostate, rectum, membranous urethra, and corpora cavernosa. The branches of the inferior vesical artery and vein that supply the bladder and prostate perforate the pelvic plexus. For this reason, ligation of the so-called lateral pedicle in its midportion not only interrupts the vessels but also transects the nerve supply to the prostate, urethra, and corpora cavernosa [2]. According to Costello et al., the branches of the pelvic plexus form three major projections: (a) anterior across the seminal vesicles and the inferolateral surface of the bladder; (b) anteroinferior across the lateral surface of the prostate; and (c) inferior between the posterolateral wall of prostate and rectum, which unites with several vessels to form the NVB [3].

7.3 Neurovascular Bundles

The inferior extension of the pelvic plexus unites with several vessels to form the neurovascular bundle of Walsh [2]. Classically this has been described as a tubular structure running along the dorsolateral aspect of prostate gland enclosed in fascial sheaths and intimately associated with the capsular vessels of the prostate. Tewari et al. [4] have shown that the NVB which they have termed the predominant neurovascular bundle (PNB) varies in shape, size, and course from the proximal to distal end. It is thickest at the base and most variable in course and architecture near the apex. In their studies in 65% of cases there was a medial extension of this bundle behind the prostate, which in 30% of cases converged medially near the midline at the apex of the prostate.

The nerves of the NVB converge at the mid-prostatic level and diverge again when approaching the apex. Since the bulk of the pelvic plexus is lateral and posterior to the seminal vesicles, they are an important anatomic landmark during surgery to avoid injury to the plexus.

There is also debate as to whether the NVB also contains the nerves responsible for continence. Strasser and Bartsch [5] proposed that the NVB contains motor and sympathetic fibers to the rhabdosphincter. Takenaka et al. [6] described twigs to the rhabdosphincter from a nerve bundle from the sphlancic nerve which contains thick myelinated fibers responsible for motor innervation of the sphincter.

7.4 Nerve-sparing Techniques and Results

Retrograde NVB preservation is the most commonly used approach during open nerve sparing radical prostatectomy [2]. This is due to the fact that the procedure is performed in a retrograde manner from apex to base. Laparoscopic prostatectomy has traditionally been performed in an antegrade manner from base to apex due to the improved visualization and appreciation of tissue planes; therefore, the majority of the laparoscopic approaches to nerve sparing incorporate some form of antegrade dissection. As with any surgical procedure, the technical approach to nerve sparing has been very dynamic and in constant flux. Recently, many centers with expertise in robotic prostatectomy have described their various approaches to nerve sparing.

7.4.1 Athermal Approaches to Nerve Sparing

It has become increasingly evident that preservation of the nerves may be achieved, yet trauma to the nerves can still diminish, delay, or eliminate recovery of erectile function. It is well known that thermal energy can significantly damage neural tissue. In a canine model, Ong and associates compared monopolar, bipolar and harmonic energy sources with conventional (without energy) dissection of the NVB [7]. Intracavernous pressure was measured immediately and 2 weeks after dissection. Dramatic decreases in intracavernous pressures at both early and late evaluations were shown in all energy groups. In fact, the decrease of intracavernous pressure was >95% in all three energy groups at 2 weeks compared with normal pressures in the conventional and control groups. It is noteworthy that studies assessing the impact of energy on nerves have usually used a myelinated nerve such as rats' sciatic nerve [8]. The cavernosal nerve, on the other hand, is an unmyelinated autonomic nerve which might be even more vulnerable to heat injury than a thicker myelinated nerve. Temperatures as low as 41°C have been proven to damage neural tissue [9].

7.4.2 Seminal Vesicle Tip Preservation to Improve Potency

In patients with favorable pretreatment features, the rate of SV invasion (SVI) is low and the distal portion of the SV may be left [10]. John and Hauri [11] suggested that sparing the SVs minimizes traction injury to the pelvic plexus and NVB, potentially improving preservation of potency. Baccala et al. [12] performed a retrospective analysis of 6740 patients who had undergone radical prostatectomy, including complete removal of the SVs. The SVI was found in 8.4% patients. For patients with positive SVs, the 5- and 10-year biochemical relapse-free survival rate was 38.0 and 25.6%, respectively. In the multivariate model SVI was found to be a significant predictor of biochemical failure ($p < 0.05$). This group also developed a nomogram based on this large population that predicts for SVI. Overall a substantial number of patients with SVI are rendered biochemically disease free at 5 and 10 years after prostatectomy alone, suggesting that complete removal of the SVs is indicated at RP to provide the best chance for cure.

7.5 Categorization of Approaches to Nerve-sparing Robotic Prostatectomy

The tremendous variability in the approach to preservation of the neurovascular bundle has often led to confusion. This is most commonly due to the fusion of various technical concepts that are used in each individual's approach. While these procedures are often a hybrid of a variety of techniques, a few fundamental concepts are part of everyone's approach. The approach to nerve sparing robotically can be antegrade, retrograde, or a combination of the two. It can be athermal or with the use of thermal energy (monopolar, bipolar, plasma kinetics, or harmonics). Another variable factor is the approach to the fascial layers surrounding the prostate at the site of the neurovascular bundle. The approach can be extrafascial, interfascial, intrafascial, or high intrafascial. We use this basic terminology to define the various approaches to robotic nerve-sparing prostatectomy.

7.5.1 Nerve Sparing in Robotic-assisted Laparoscopic Prostatectomy

7.5.1.1 The Henry Ford Technique: the Veil of Aphrodite

The surgeons at Henry Ford Hospital have described an athermal antegrade approach that involves a high intrafascial approach to nerve sparing. The rationale for this approach is upon the basis of new information suggesting that in many instances an anterior and posterior plexus of nerves exists innervating the cavernous tissues, rectum, and prostate, in contrast to two distinct NVBs [13]. This plexus crosses the midline posterior within the layers of Denonvilliers' fascia and extends to the anterolateral surface of the prostate in the prostatic fascia. The prostatic fascia on the anterolateral surface of the prostate is rich in nerve tissue that may be important in penile erection. Based on these findings, to promote earlier return of potency, investigators from Vattikuti Urology Institute embarked on a feasibility study to examine whether it was technically possible to preserve the prostatic fascia in some men undergoing robotic radical prostatectomy. They have recently published promising results with this new technique [14, 15]. Once the seminal vesicles are lifted anteriorly to demonstrate the longitudinal fibers of the posterior layers of Denonvilliers' fascia near the base of the prostate, it is incised sharply until prerectal fat is seen. Use of electrocautery is avoided for the entire posterior dissection, so that the NVBs are not damaged by conducted heat. Once the proper plane is entered, the authors dissect between the layers of the Denonvilliers' fascia to leave a protective layer of fascia over the rectum and any network of nerves in this area. The plane between the posterior prostate and Denonvilliers' fascia is extended as far distally as possible, and then the base of the seminal vesicle is retracted superomedially by the assistant, and the prostatic pedicle is delineated and divided. The pedicle lies anterior to the pelvic plexus and NVB, and includes only the prostatic blood supply. Under magnification of the robotic camera, several arterial branches can be seen and controlled individually. The pedicle is divided sharply with cold scissors. The NVB runs along the posterolateral aspect of the prostate encircled by the inner (prostatic) and outer (levator) layers of the prostatic fascia and the posterior layer of Denonvilliers' fascia. After dividing the pedicle, the plane between the prostatic capsule and inner leaf of the prostatic fascia is developed at its cranial extent. Once this is accomplished, the assistant provides superomedial prostate retraction and lateral retraction on tissues adjacent to the NVB. This allows the surgeon to enter a plane between the prostatic fascia and the prostatic capsule. The correct plane is between the prostatic venous plexus and the surface of the prostate and is developed with blunt dissection with the articulated scissors, using bipolar coagulation only as necessary. Meticulous sharp and blunt dissection of the NVB and contiguous prostatic fascia is performed until the entire prostatic fascia, up to and including the ipsilateral pubourethral ligament, is mobilized in continuity of the lateral aspect of the prostatic apex. This plane is generally avascular, except anteriorly, where the fascia is fused with the puboprostatic ligament, capsule, and venous plexus. At the end of a correct dissection, an intact veil of tissue should hang from the pubourethral ligament. The authors state that the thickness and vascularity of the veil is variable. In the presence of large prostates, the veil is delicate, and in men with small prostates the

veil is robust and vascular. The authors call this dissected prostatic fascia the "veil of Aphrodite" [14].

In a series comparing various aspects between robotic RP (classic nerve sparing) and open RP, investigators from Vattikuti Urology Institute reported potency preservation results in favor of robotic surgery [16]. The odds ratio of median time to erection and to intercourse was 0.4 and 0.5, respectively, when the values for open prostatectomy were used as reference values. More recently the same group published their results on potency following robotic radical prostatectomy comparing conventional nerve sparing and prostatic fascia-sparing techniques [15]. A total of 58 potent men with Sexual Health Inventory for Men Score (SHIM) of greater than 21 without phosphodiesterase-5 inhibitors underwent Vattikuti Institute prostatectomy, including 35 with preservation of the fascia and 23 with conventional nerve sparing. Potency was assessed with self-administered SHIM questionnaires 12 months after surgery. The primary end point was achievement of erections strong enough for penetration with or without oral medications. At 1-year follow-up, 74% of patients in the conventional nerve sparing group, and 97% of those who underwent the fascia preserving approach achieved erections strong enough for intercourse ($p = 0.002$). Erections were achieved without the aid of medication in 17% of conventional nerve-sparing group and 51% in prostatic fascia-preserving group. The authors stated that erectile function outcomes achieved with prostatic fascia preservation was the highest reported in the literature. Recovery of potency required 9–12 months. They hypothesized that the excellent outcome in the study patients were related to the preservation of additional erectile nerves in the prostatic fascia. Nevertheless, they stated that they have not performed microdissection studies which trace accessory nerve channels to the corpora cavernosa; therefore, it would equally be possible that the enhanced erectile function was the result of decreased traction or thermal injury to the nerves, since the plane of dissection was far away from the putative NVBs. They proposed a third possibility of preservation of the prostatic fascia maintaining additional blood supply to the cavernous tissue, allowing the production of more endothelial nitric oxide, which is the factor responsible for the maintenance of penile erection; however, there were several caveats: This was a nonrandomized trial and patients in the study group were younger and had lower risk disease. While patients self-administered the mail-in questionnaire, data collection and analysis were done by individuals directly involved with surgical treatment. The investigators offer the fascia-sparing technique to men with low-risk disease (PSA <10 ng/ml, clinical stage T1c and Gleason sum 6 or less).

7.5.1.2 The Ohio State Technique: Athermal Early Retrograde NVB Release During Antegrade Prostatectomy

We have recently described a unique robot-assisted laparoscopic approach to nerve sparing, modeled upon the fusion of traditional open and standard laparoscopic surgical technique. While the majority of the procedure is performed in the standard antegrade laparoscopic manner, the nerve sparing is performed retrograde as in traditional open surgery from apex to base. The basic premise is that the neurovascular bundle can best be identified and released at the apex of the prostate and delineated

back to the pedicle avoiding the possibility of inadvertent damage while controlling the pedicle, a possibility that is present during the antegrade laparoscopic approach.

Once the seminal vesicles have been mobilized, the anterior and posterior layers of Denonvilliers' fascia are separated to develop the posterior space. The prostate is then elevated to identify the lateral attachments. It is of great importance to fully dissect the posterior space and release the rectum from the posterior surface of the prostate as this improves the ability to rotate the prostate. Once this has been performed, the nerve sparing can proceed. The technique involves incision of the periprostatic fascia at the level of the apex and midportion of the prostate. Gentle spreading of the tissue on the lateral aspect of the prostate will allow the prostatic capsule and the neurovascular bundle to be identified. No thermal energy is used during dissection of the NVB or ligation of the pedicle. At the apex of the prostate a plane between the NVB and prostate capsule can be identified and separated. The NVB is then released in a retrograde manner towards the prostatic pedicle. The NVB is stabilized with the Maryland dissector and the prostate is gently stroked away using the scissors. The plane between the NVB sheath and the prostate capsule is relatively avascular consisting of only small tributary veins; therefore, no energy or clipping is required close to the path of the NVB. As the dissection proceeds in a retrograde fashion the NVB can clearly be seen being released off of the prostate. The prostate pedicle can then be thinned out with sharp dissection and the path of the NVB clearly delineated at this level. The clear definition of the anatomy allows the placement of two clips on the pedicle away from the NVB and sharp incision to release the prostate completely. This identical procedure can be performed bilaterally, completely releasing the prostate.

Between March 2006 and December 2006, 397 patients with localized prostate cancer underwent nerve-sparing RALP by the modified technique [41]. Bilateral nerve-sparing procedure was performed in 233 (58.7%) patients, unilateral nerve sparing in 51 (12.8%), and non-nerve-sparing technique was used in 113 (28.4%) patients. Of these patients, 110 patients with preoperative SHIM score >22 (Preop potent), who underwent unilateral or bilateral nerve-sparing procedure and had at least 3 months of postoperative follow-up, were analyzed. Of 110 patients, 93 (84.5%) patients were

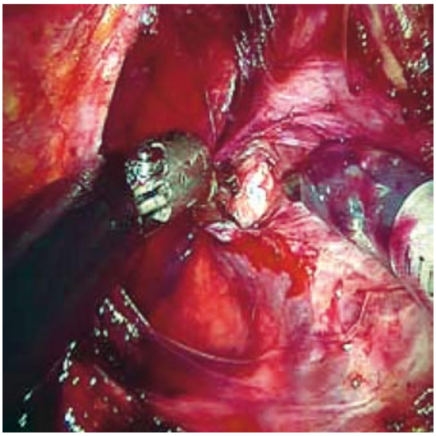

Fig. 7.1 Identifications of the Neurovascular bundle (NVB). Scissor tips are spread in the plane between the prostate capsule and the NVB. The Maryland dissector is used to stabilize the NVB while the scissors are used to push the prostate away from the NVB. A separation is created between the lateral prostatic capsule and the NVB. Minor non-arterial bleeding should be tolerated, as it will stop

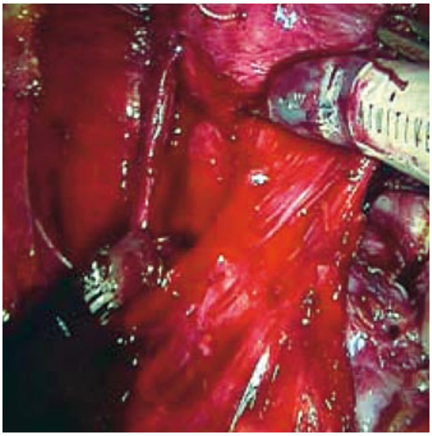

Fig. 7.2 Identification of planes. Precise plane dissection between the NVB and the lateral prostate is performed and great care is taken to visualize this junction to avoid capsular incision

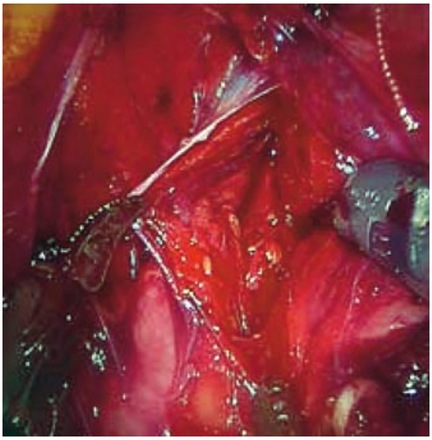

Fig. 7.3 Retrograde dissection to identify the prostate pedicle. The NVB is then released in a retrograde manner from apex to base to identify the path of the bundle. (Caution: the NVB kinks up and travels millimeters from the base of the prostate and therefore is at risk of being clipped if not identified and released.)

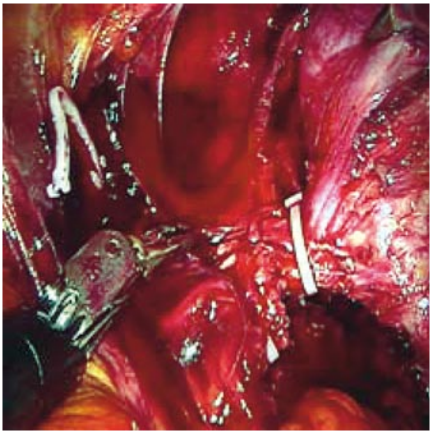

Fig. 7.4 Clipping of the pedicle. Complete path of the NVB is delineated from apex to base at the level of the prostate pedicle. The prostate is then rotated laterally and the pedicle is clipped under direct vision while clearly visualizing the path of the NVB at the base of the prostate; 10 mm hem-o-lock clips are used to ligate the pedicle and are then divided with cold scissors

potent with or without use of PDE-5 inhibitors. Fifteen (13.6%) patients were potent immediately after catheter removal, 27 (24.5%) were potent at 1 month follow-up, 81 (73.3%) were potent at 3 months follow-up, 91 (82.7%) were potent at 6 months follow-up, and 93 (84.5%) were potent after 12 months of follow-up. Another group of 57 patients with preoperative SHIM score between 17 and 21 (mild erectile dysfunction) with unilateral or bilateral nerve-sparing procedure, and who had at least 3 months of postoperative follow-up, were analyzed. Of these 57 patients, 40 of 57 (70.1%) patients were potent with or without use of PDE-5 inhibitors. Five (8.7%) patients were potent immediately after catheter removal, 11 (22%) were potent at 1 month follow-up, 31 (62%) were potent at 3 months follow-up, 39 (68%) were potent at 6 months follow-up, and 40 (70.1%) were potent after 12 months of follow-up.

7.5.1.3 UC Irvine: Antegrade Clamp and Suture Technique

In an effort to protect neural tissue from both thermal damage from energy sources and mechanical trauma from clipping, two centers reported using vascular clamps and suture ligation for controlling the prostatic pedicle. In the robotic technique of investigators from the University of California at Irvine, after mobilizing the prostate off the rectum, prostatic vascular pedicles are delineated and thinned. Laparoscopic bulldog clamps of 30 mm are placed on the vascular pedicles at least 1 cm from the prostate [17]. From this point, only cold scissors are used to divide the vascular pedicles very close to the prostate. The lateral fascia is incised along the prostate, and the NVB is gently dissected off the prostatic capsule. After complete mobilization of the NVB down to the urethra, the authors initially applied FloSeal (Baxter) along the entire length of the NVB. FloSeal was then covered with a dry 1 × 5 cm sheet of Gelfoam (Pfizer, New York, N.Y.) to act as a protective cover to keep the FloSeal particles in place. In a more recent report, they reported that hemostatic agents failed to control bleeding acutely approximately 20% of the time, and thus they abandoned their use in favor of time-proven suture ligature [8]. The investigators now control the vessels in the vascular pedicles using a running 3-0 polyglycolic acid suture ligature. Prior to removing the bulldog clamp, two throws are placed through the vascular pedicle. The bulldog clamp is then removed, and the suture is used to display the remaining vessels such that precise needle placement is facilitated to avoid injury to the NVB. If pulsatile bleeding is seen along the NVB, precise ligature of the bleeding site is performed with a 4-0 suture on an RB needle. The authors state that suturing is very much facilitated by the 10–12× magnification and precise suturing skills of the robot. They reported nearly a fivefold increase in return of early sexual function with this cautery-free technique compared with the group on whom they operated with bipolar cautery when dividing the vascular pedicle (43 vs 8.3%). They also attempted to assess partial recovery. Cautery-free group reported 18% zero fullness at 3 months, whereas this rate was nearly 70% in the bipolar energy group. In the University of California at Irvine experience, men were selected for excision of one or both NVBs, if the patient had extensive involvement noted on biopsy cores (more than 50% by volume estimate and/or Gleason score greater than 4+3), obvious palpable disease (with biopsy confirmation), inadequate sexual function (SHIM score less than 10), or patient preference.

7.5.1.4 University of Chicago: Antegrade Thermal Clipless Approach

Investigators from the University of Chicago modified the antegrade method originally described by Kursh and Bodner [19]. Upon division through the bladder neck, the plane between both layers of Denonvilliers' fascia is identified and developed, separating the prostate from the rectum. Dissection in this plane is carried out distally toward the apex of the prostate. The thick lateral pedicles of the prostate then become prominent on both sides. Using a combination of mostly blunt and some sharp dissection with cold scissors, the vascular pedicles are teased off the prostatic pedicle. Proceeding in a medial to lateral dissection in this posterior plane, the vascular pedicles are released prior to the NVBs. The vascular pedicles are further mobilized in an anterior direction until the most distal ends are identified just before penetrating into the prostatic capsule. These small vessels are cauterized at their most distal ends using only bipolar cautery. The vascular pedicles are then swept off the prostate further mobilizing the NVBs, which are then dissected sharply from the prostatic capsule. The dissection continues with peeling off the periprostatic fascia, NVB, and the prostate pedicle en bloc until the urethra is reached. Bulk clipping of the pedicles is eliminated by dividing them as they enter the prostate, since the branches are less then 1 mm in diameter at this level. Dissection with a clipless technique with bipolar energy is similar to that described by Guillonneau and Vallancien [20]; however, Chien et al. [18] carry out the dissection from medial to lateral, opposite of the other technique. Alternatively, in an effort to avoid any thermal energy use, clipping of the prostatic pedicles is also a viable option; however, there is concern that bulk clipping may injure some nerve fibers responsible for erection. Chien et al. [18] also propose that after having initially mobilized the NVBs, the thermal spread may be theoretically diminished secondary to the increased distance achieved between the NVB and prostatic capsule. Figure 7.5 depicts bilaterally preserved NVBs during a robotic radical prostatectomy. Using a validated sexual function questionnaire, Chien et al. [18] found that, at 1 month, patients returned to 47% of their baseline preoperative sexual function scores. At 3, 6, and 12 months, this rate increased to 54, 66, and 69%, respectively. This was a small series and only 6 patients reached 1 year of follow-up.

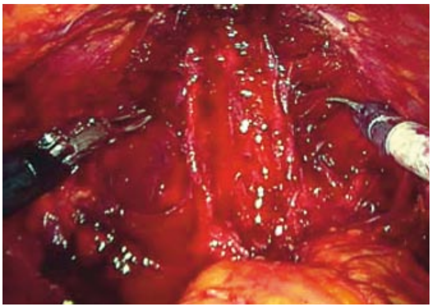

Fig. 7.5 Preservation of NVBs. Both NVBs can clearly be seen.

7.5.2 Nerve Sparing in Laparoscopic Radical Prostatectomy

7.5.2.1 Cleveland Clinic: Clamp-and-Suture Technique with Ultrasound Guidance

Utilization of vascular clamps for controlling the vascular pedicle during conventional laparoscopic radical prostatectomy was reported by the Cleveland Clinic [21]. Once the pedicle is dissected out, a 25-mm straight atraumatic bulldog clamp (CEV565, MicroFrance Medtronic Xomed, Jacksonville, Fla.) is placed obliquely at a 45° angle across the pedicle of the prostate close to the bladder neck, at some distance from the posterolateral edge of the prostate. Using cold scissors, the lateral pedicle is divided, leaving an approximately 1- to 2-mm edge of pedicle tissue extending beyond the jaws of the bulldog clamp. Importantly, transrectal ultrasound (TRUS) imaging provides real-time guidance along the posterolateral edge of the prostate, minimizing inadvertent compromise of the prostatic capsule. Once the last few remaining attachments of the lateral pedicle are divided, the NVB becomes evident. At this point, the NVB is released in an antegrade manner along the convexity of the prostate toward the apex using a combination of both sharp and blunt dissection. Complete avoidance of thermal energy keeps the appearance and color of tissues unchanged, aiding in a more precise dissection in the correct plane. At this time, 4-0 polyglactin suture on an RB-1 needle cut to 6–8 cm is used to suture the transected lateral pedicle superficially. The bulldog clamp is removed next, and any bleeding vessels are meticulously sutured for hemostasis. TRUS measurements are obtained both before and during the application of the bulldog clamp, and at prostatectomy completion. The TRUS parameters evaluated include the dimensions of the NVB, number of visible vessels, and resistive index of arterial flow within the NVB [22].

When the investigators from the Cleveland Clinic initially used vascular clamps to control the pedicle, they extrapolated from their experience with hemostatic bioadhesives during laparoscopic partial nephrectomy, and evaluated the use of FloSeal; however, parallel to the experience at the University of California Irvine, FloSeal could not achieve reliable hemostasis of bleeding vessels from the prostate pedicle and the NVB. Another concern brought up by the authors was about the healing process after topical application of bioadhesives, which might result in reactionary fibrosis, exuberant lymphocytic infiltrate, and an inflammatory response [22]. In this technique, one could question whether the bulldog clamp itself imposes mechanical trauma to the delicate fibers of the NVB. Nevertheless, the major structure controlled by the bulldog clamp is the lateral pedicle containing the distal branches of the inferior vesicle artery to the prostate base and bladder neck, and not the NVB [21]. The TRUS demonstration of continued pulsatile blood flow within each NVB during active bulldog clamping is encouraging, suggesting that minimally occlusive pressure is imposed on the NVB. The investigators believe that the lateral prostate pedicle is thicker in size than its underlying thinner NVB; therefore, placement of the bulldog clamp on the overlying bulkier prostate pedicle likely does not compress the underlying NVB. The resistive index of arterial flow within each NVB remains the same. Some bleeding is reported to occur from the transected blood vessels of the lateral pedicle, indicative of the relatively gentle occlusive force of the vascular clamps; thus, direct trauma to the cavernous nerve fibers is unlikely. The potency data are still awaited.

7.5.2.2 Heilbronn Technique

In the Heilbronn technique popularized by Rassweiler et al. [24], the lateral pelvic fascia is incised prior to the incision of the urethra and positioning the prostate on its side exposes the lateral surface of the prostate. A right-angle clamp is inserted under the lateral pelvic fascia beginning at the bladder neck and extending distally towards the apex of the prostate to detach the area of the NVB from the posterolateral border of the prostate and dissect it gently from the apical part of the prostate. All the prostatic branches of the NVB are managed one by one with 5-mm titanium clips and use of bipolar or monopolar cautery is avoided.

7.6 Discussion

Prostate cancer diagnosis has seen a significant stage migration with the introduction of PSA testing. Men diagnosed today typically are of younger age and present at an earlier disease stage than was seen in the pre-PSA era. These patients are offered numerous radical treatment options for a malignancy with a long natural history. Functional outcomes from these treatments are one of the most important aspects in prostate cancer management for both the patient and urologist.

Crawford et al. conducted a telephone survey of 1000 men in the prostate cancer support group US TOO. They found that for 45% of men, preservation of quality of life was the most important goal for prostate cancer treatment, compared with 29% who chose extension of life [25].

Singer et al., interviewing 50 men without prostate cancer, demonstrated that 68% would trade at least a 10% survival advantage to maintain potency [26]. Helgason et al. used a self-administered patient questionnaire and found that sexual dysfunction was the most distressing symptom among prostate cancer patients [27]. They also reported a significant proportion of men willing to consider a trade-off between life expectancy and intact sexual function [28]. While the results of prostate cancer treatment studies and their effects on quality of life are conflicting, there is a recent trend suggesting that functional outcomes do indeed influence patient quality-of-life scores.

We studied a unique patient population at The Ohio State University that was referred to us for consultation for robotic prostatectomy to determine their motivating influences [42]. A total of 800 patients were referred for consultation regarding potential robotic prostatectomy. These patients were asked questions regarding referral source, demographics, medical history, and what their own motivation was for coming. The most common reason for patients having an interest in robotic surgery was the possibility of decreased morbidity (54%), potentially improved outcomes (37%), and other reasons (9%). Of the 540 patients who came to primarily explore the decreased morbidity associated with robotic surgery, the most common concerns were: blood loss/transfusion (57%); pain (31%); and recovery (12%). For those concerned more about outcomes the key issues were: cancer control (41%); potency (39%); and continence (20%). From this study we found that for patients with prostate cancer potency was just as important as cancer control.

Since Binder and Kramer first reported RALP in 2000, the technique has evolved considerably [29]. Centers of excellence continue to refine their technique demon-

strating improved outcomes. Factors associated with better return of postoperative erectile function include younger age, better preoperative potency, ability to perform unilateral or bilateral nerve-sparing procedures, and implementation of postoperative penile rehabilitation programs [30–35].

Identification and delineation of the path of the NVB and avoidance of trauma are crucial in maintaining erectile function. The key issue in nerve-sparing prostatectomy is to minimize trauma to the NVB which can result from direct trauma during dissection, thermal injury due to electrocautery, and neuroprexia due to traction on the nerves. It is important to identify potential anatomical sites where NVB can be injured during radical prostatectomy. Most centers now perform athermal dissection using clips or clamps in order to avoid thermal damage to the neuronal tissue. Factors such as patient age, preoperative potency, and unilateral or bilateral nerve preservation also affect postoperative return of erectile function.

7.7 Conclusion

Erectile dysfunction is the most frequent long-term quality-of-life compromise faced by men undergoing treatment for carcinoma of the prostate. Thus improvements in technique that would hold promise for better potency preservation represent a significant advance in the field of prostate cancer surgery. Robot-assisted laparoscopic surgery has various advantages such as magnified vision and wristed instrumentation, which have the potential to facilitate nerve-sparing radical prostatectomy. If these technical advantages translate to higher-quality surgery with superior outcomes, robotic radical prostatectomy appears to have the potential to improve erectile function preservation after prostate cancer surgery. Early reports have been promising.

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Table 7.1 Potency outcomes following Robotic and laparoscopic Radical Prostatectomy

Reference	No.	Evaluation	Follow-up (months)	UNS	BNS	Mean age (years)	Erections (%)	Intercourse (%)	PDE-5 inhibitors
[15]	2652	Questionnaire	12	663 (Veil)	875 (Veil)	57.4 (42–68)	–	70 (BNS)	50
			48					100 (BNS)	
[18]	56	Questionnaire	6	20	28	58.9 (43–70)	–	37.5	±
[17]	23	Questionnaire	3	6	17	55.7 (48–65)	43	–	±
V. Patel [41]	397	Questionnaire	12	51	233	61.1 (35–79)	84.5	–	±
[36]	550	Questionnaire	10 (1–39)		47	<70	85 (BNS)	66 (BNS)	33
[37]	177	Questionnaire	12	57	89	–		48	±
								76 (BNS)	
[38]	125	Interview	<15	11	89	59.9		59 (BNS/UNS)	±
[39]	5824	Questionnaire	60	–	3058	–	52.5 (BNS)		±
							(35–67)		
[40]	143	Questionnaire	12	30	63	64	30 (NNS)	23	0
							50 (UNS)		
							87.5 (BNS)		

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Chapter 8

Vattikuti Institute Prostatectomy: Veil of Aphrodite Nerve-sparing Technique

Alok Shrivastava,
James O. Peabody, Mani Menon

8.1 Introduction

When laparoscopic radical prostatectomy was first described in 1992, its innovators were concerned that the procedure took too long and offered little advantage over conventional retropubic radical prostatectomy [1]. It was only after the pioneering work of Guillonneau et al. [2], and Abbou et al. [3], that there was a resurgence of interest in the procedure. Nonetheless, many urological surgeons feel that the procedure is exceedingly difficult to master and may offer little benefit to the patient [4].

The development of the surgical robot has changed this. With stereoscopic vision, wristed instruments and scaled intuitive movements, this large and complex device has empowered surgeons trained in radical retropubic prostatectomy to transition to minimally invasive surgery for prostate cancer.

In 2000 at the Vattikuti Urology Institute, we established a structured program for robot-assisted radical prostatectomy using the Da Vinci Surgical System (Intuitive Surgical, Sunnyvale, Calif.) in 2001 [5]. We started by learning the fundamentals of laparoscopic prostatectomy and transitioning to robotic-assisted prostatectomy under the supervision of expert mentors. Due to the expertise gained from the training and the improved instrumentation of the robot, we were able to develop a safe, teachable, and reproducible technique for robotic-assisted laparoscopy. The ease of learning and improved functional outcomes has made this procedure increasingly accepted by the urologists and their patients across the United States. It is estimated that almost 50% of patients undergoing radical prostatectomy in 2007 will opt for the robotic approach.

In this article we present our current technique of robotic radical prostatectomy – The Vattikuti Institute Prostatectomy (VIP) – and describe an extended nerve sparing of the lateral prostatic fascia which we call the veil of Aphrodite. We believe that this technique minimizes morbidity and maximizes functional outcomes.

8.2 Indications and Patient Selection

Indications for the VIP are identical to those for open radical prostatectomy: patients who have localized prostate cancer with biologically significant disease and a life expectancy more than 10 years.

While patient preference drives the decision to undergo surgery, we generally recommend that men with low PSA and focal Gleason 6 cancer of the prostate undergo active monitoring with follow-up biopsies. We offer surgery for men with nonfocal Gleason 6 cancer (30% of our patients), Gleason 7 (60%), and Gleason 8–9 cancer (10%). Patients with >25% Gleason 7 disease get conventional nerve sparing [6, 7] on the ipsilateral side: all others get the veil nerve sparing [8].

8.3 Setup

8.3.1 Operating Room

The Da Vinci surgical system is a sophisticated master–slave device. It has a surgical cart with three or four multijointed arms, one controlling a binocular endoscope and the others controlling articulated instruments inside the patient's body. This is the

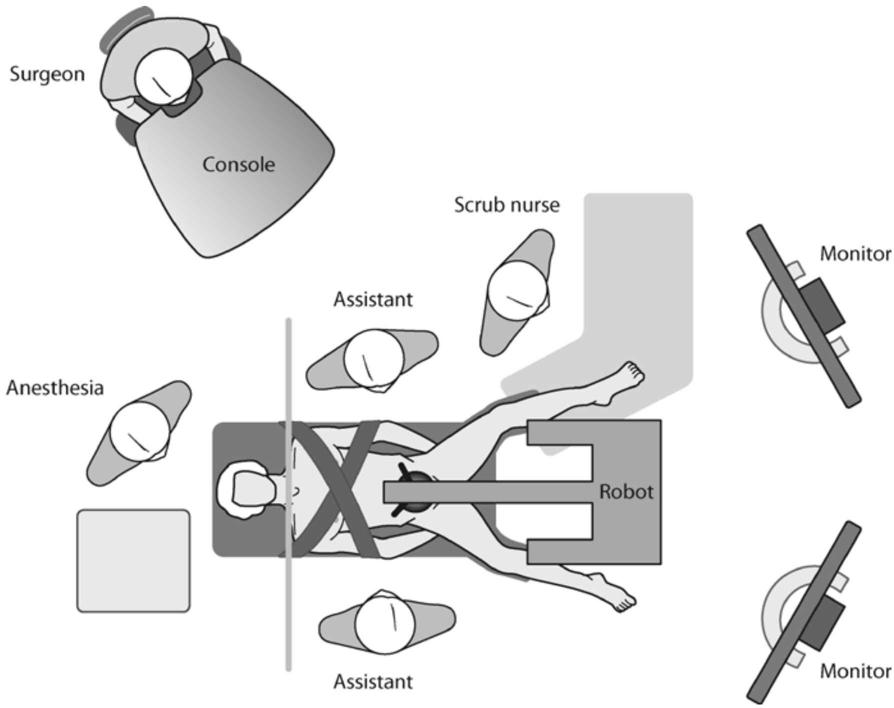


Fig. 8.1 Operating room setup. (From [18])

"slave" component of the system which is controlled by the surgeon's console. The surgeon console has two master arms. The surgeon moves the masters, and these movements are translated in real time into movements of the instrument tips inside the patient's body. The master arms can be made to control camera movements by pressing a foot pedal. The surgeon has a stereoscopic or 3D display of the operating field. We also have custom-built 3D display system for the assistants (Fig. 8.1).

8.3.2 The Surgical Team

The Vattikuti Institute Prostatectomy Team includes one console-side and two patient-side surgeons and a scrub nurse. The operating surgeon sits at the console and is not scrubbed. The patient-side team is scrubbed and uses laparoscopic instruments to present the operative field to the operating surgeon.

8.3.3 Instruments

Surgical team's familiarity with the robotic instruments and consumables facilitates quick change of instruments and faster troubleshooting. Dry lab experience for the surgical team to practice on the robotic instruments is strongly recommended. The robotic instruments have been continuously evolving. The following is a list of instruments currently used by our team.

8.3.3.1 Robotic Instruments

The ports are two robotic 8-mm, four laparoscopic ports with dilating-tip trocars (12 and 5 mm two each, two 12- to 5-mm port reducer caps). The instruments used for the robotic arms are: 0 and 30° binocular telescope; sterile arm drapes; sterile adapters for the instrument arms; Endowrist monopolar hook cautery; Endowrist bipolar graspers; Endowrist round tip scissors; and two Endowrist needle drivers. (All robotic instruments are supplied by Intuitive Surgical, Sunnyvale, Calif.)

8.3.3.2 Laparoscopic Instruments

The instruments used by patient-side assistants are: Veress needle; laparoscopic graspers; suction irrigator with long suction cannula; laparoscopic scissors; laparoscopic needle drivers; specimen retrieval bag; and laparoscopic clip appliers.

8.3.3.3 Sutures

The sutures are: an 0-Vicryl (Polyglactin 910) suture on a CT-1 (36-mm, taper) needle; 2-0 Vicryl (Polyglactin 910) suture on and RB-1 (17-mm taper) needle; two 3-0 Monocryl (Poliglecaprone 25) sutures on an RB-1 (17-mm taper) needles, one dyed and one undyed; 0 Ethibond (braided polyester) suture on CT-1 (36-mm, taper) nee-

dle; and 4-0 monocryl (Poliglecaprone 25) suture on PS2 (19-mm reverse cut) needle. (All sutures are supplied by Ethicon Inc., Somerville New Jersey)

Additionally, a high-flow pneumo-insufflator and an electrocautery machine are needed.

8.4 Technique of VIP

8.4.1 Specific Patient Preparation

In preoperative counseling the VIP procedure and other treatment options are discussed with the patient. A brief review of our and others' published results is also discussed.

We wait at least 6 weeks after prostatic biopsy before the surgery. This time allows resolution of periprostatic inflammation and hematoma caused by the biopsy. After TURP, we recommend waiting 3–4 months. Discontinuation of aspirin and antiplatelet agents is required for at least 2 weeks before surgery, because even minimal bleeding obscures vision and can make the dissection less precise.

Preoperative work-up includes complete blood counts, electrolyte and coagulation profiles. A chest X-ray and EKG are also obtained. In patients with significant cardiac history preoperative cardiac clearance is obtained. Anticoagulation, if any, is stopped 2-4 weeks prior to surgery in consultation with the ordering physician.

The patient takes a clear liquid diet and uses a laxative 1 day before surgery. Antibiotic prophylaxis is given before surgery per hospital protocol. A combination of intermittent compression stockings and subcutaneous heparin, 5000 units, is used pre- and postoperatively during the hospital stay.

All patients are placed under general anesthesia with endotracheal intubation and muscle relaxation. Because of the relative lack of bleeding during the procedure, large amounts of intravenous fluid replacement are not necessary. It is suggested to restrict intravenous fluids to 600–800 ml during the initial portions of the case until anastomosis is performed. This obviates excessive production of urine during the surgery, decreasing the need for suction maneuvers to clear the field. After the anastomosis, the patient is given 1 l of intravenous fluid.

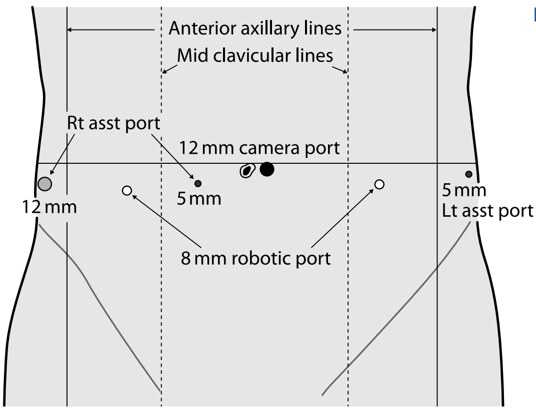


Fig. 8.2 Port placement. (From [19])

8.4.2 Patient Positioning and Port Placement

The patient is padded at pressure points and placed in lithotomy position. He is secured to the table with crossed straps. The table is then moved to a steep Trendelenburg position. Pneumoperitoneum is created and ports are placed, and we use a six-port transabdominal approach (Fig. 8.2)

8.4.3 Development of the Extraperitoneal Space

The peritoneal cavity is inspected using the 30° upward-looking lens. A transverse peritoneal incision is made extending from the left to the right medial umbilical liga-

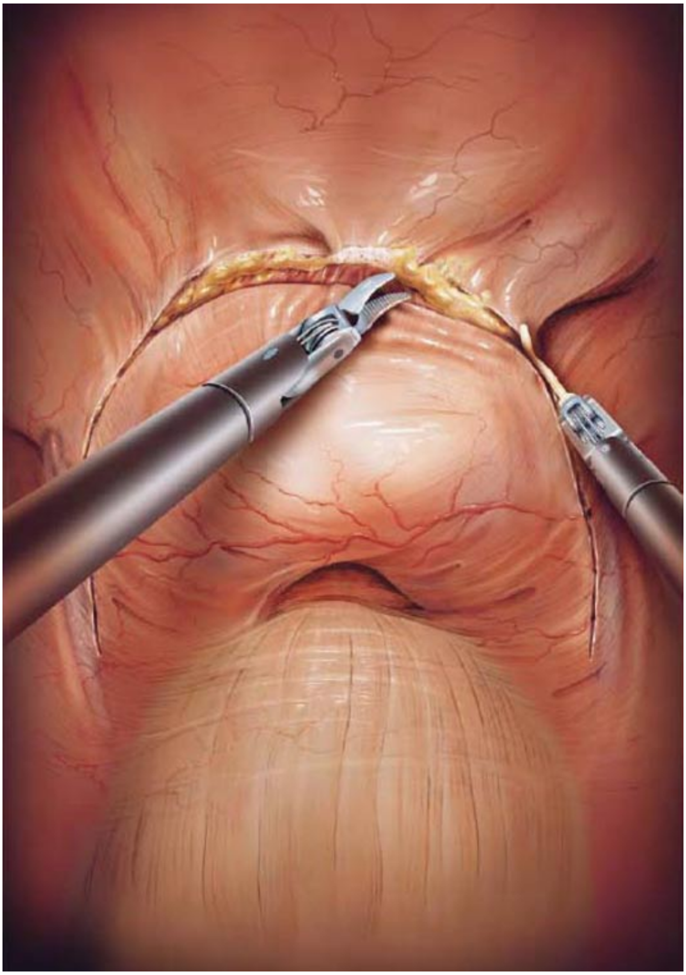


Fig. 8.3 Development of extraperitoneal space. (From [18])

ment. This incision is extended in an inverted U to the level of the vasa on either side. The space anterior to the peritoneum and space of Retzius is entered (Fig. 8.3). The rest of the surgery is performed in this space anterior to the peritoneal reflection of the bladder and prostate.

8.4.4 Lymph Node Dissection

The tissue overlying the external iliac vein is incised and lymph nodal package is pushed medially. The dissection is started at the lymph node of Cloquet at the femoral canal and continued proximally toward the bifurcation of iliac vessels. The obturator nerve lies on the floor of this dissection and is carefully preserved. (Fig. 8.4). In patients with Gleason 8–9 disease the lymph node dissection is extended, and the nodal package between the obturator nerve and the hypogastric vein is also removed.

8.4.5 Bladder Neck Transection

We generally approach the bladder neck dissection without opening the endopelvic fascia or ligating the dorsal vein complex, a modification over our previously described technique [9]. This portion of the procedure is best done with a 30° lens looking down. The right assistant grasps the anterior bladder wall in the midline with an atraumatic grasper and retracts it cephlad and anteriorly. The left assistant deflates the Foley balloon and keeps the catheter in the bladder. This simple maneuver aids in the identification of the bladder neck, as the bladder pulls away from the prostate excepting at the midline anterior to the catheter. A detrusor apron may be seen on the anterior surface of the prostate [10]. A 3-cm incision is made transversely in the anterior bladder neck at the 12 o'clock position immediately superior to the detrusor apron, cutting down the detrusor to expose the catheter in the midline (Fig. 8.5).

After the anterior bladder neck is opened, the left-side assistant grasps the tip of the Foley catheter with firm anterior traction. This exposes the posterior bladder neck, which is incised (Fig. 8.6).

The posterior bladder neck is gradually dissected away from the prostate, taking care to leave a thin layer of detrussor tissue on the prostate to avoid a positive surgical margin at the prostatic base. A tissue layer anterior to and covering the vasa and the seminal vesicles is now exposed. This layer is incised transversely, exposing the vasa and the seminal vesicles. The left-side assistant provides upward traction to the posterior base of the prostate to facilitate dissection of the vasa and seminal vesicles (Fig. 8.7).

First the vasa are skeletonized and transected, then held upward by the left assistant providing further traction for dissection of the seminal vesicles (Fig. 8.8). The artery to the seminal vesicle is controlled by clipping or fine bipolar coagulation.

Both the vasa and seminal vesicles are then grasped and the posterior prostate is retracted upwards, allowing exposure of posterior layer of the Denonvillier's fascia. An incision is made in this fascia and a plane is developed between the posterior layer of the Denonvillier's fascia and perirectal fat. This avascular plane can be created easily using blunt dissection (Fig. 8.9).

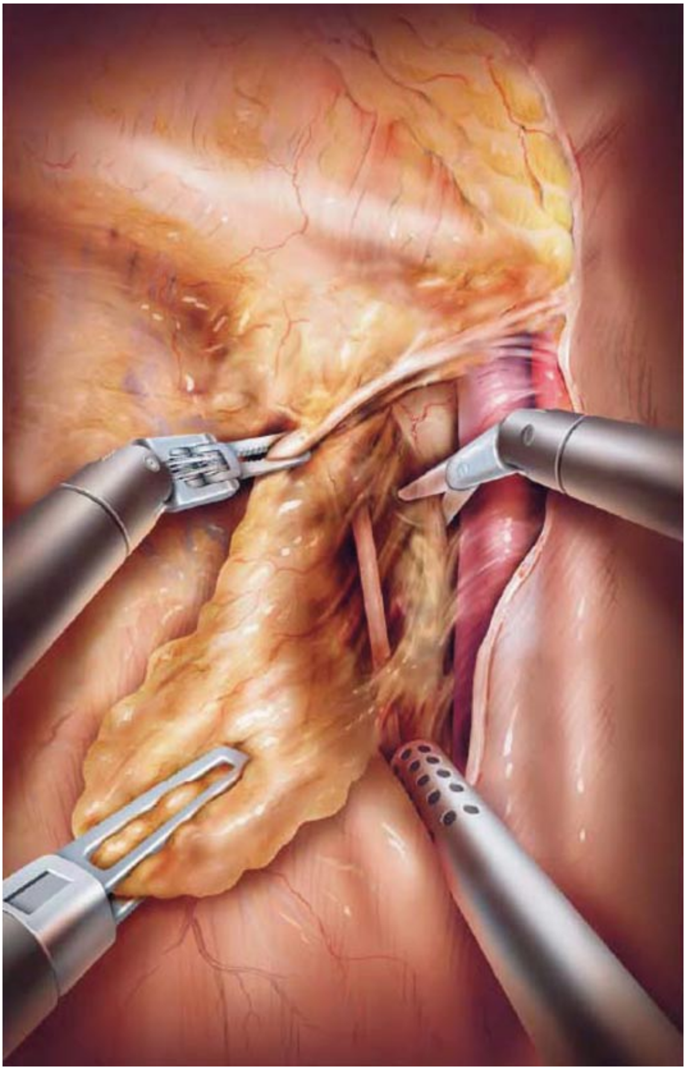


Fig. 8.4 Right pelvic lymph node dissection. (From [18])

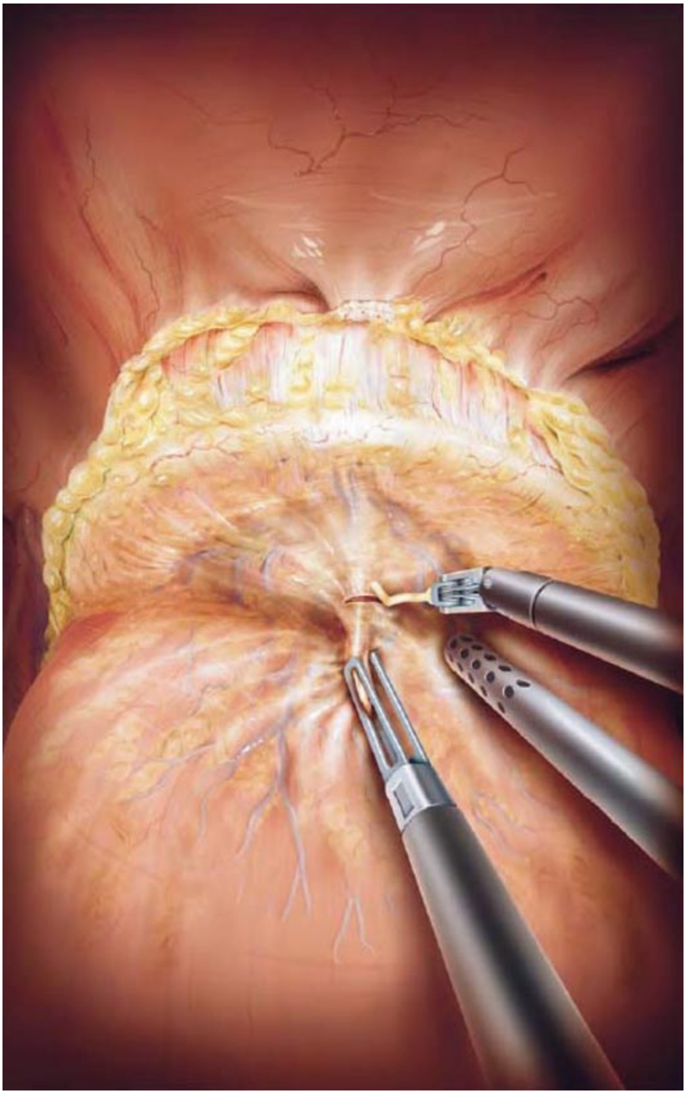


Fig. 8.5 Incision of anterior detrussor wall at bladder neck. (From [18])

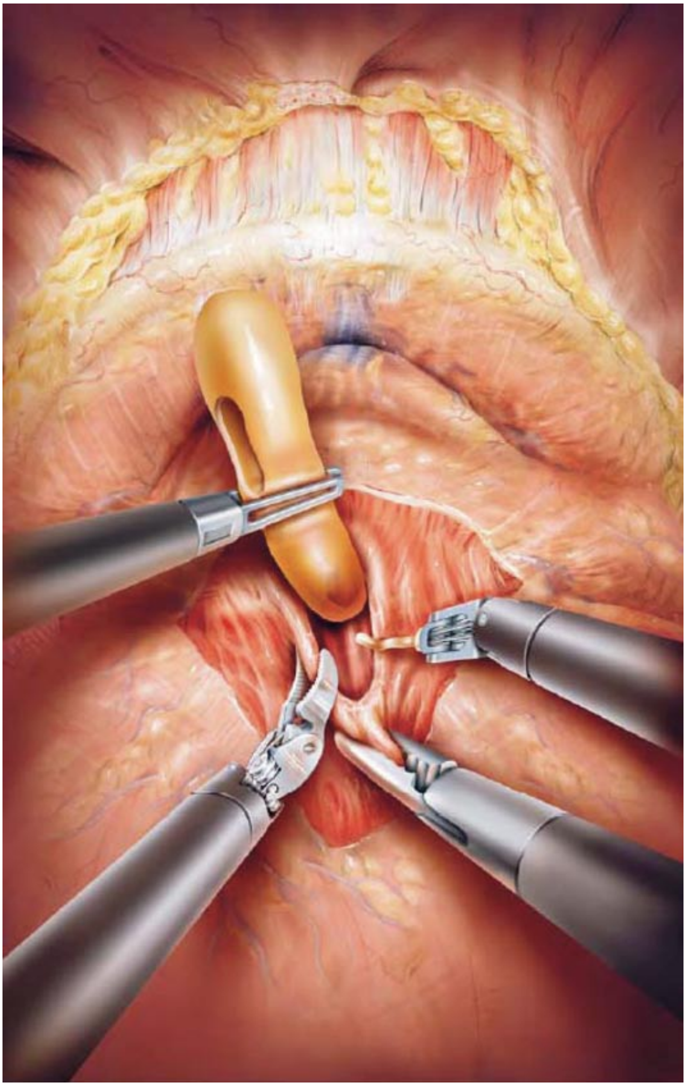


Fig. 8.6 Incision of posterior detrussor wall at bladder neck. (From [18])

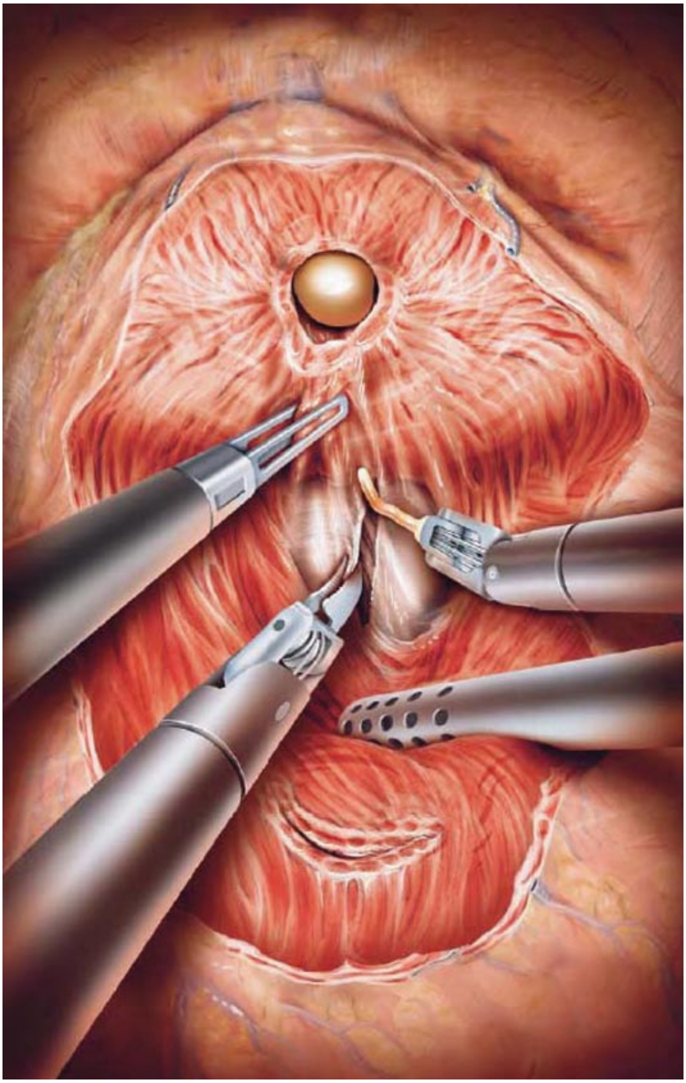


Fig. 8.7 Exposure of anterior layer of Denonvillier's fascia. (From [18])

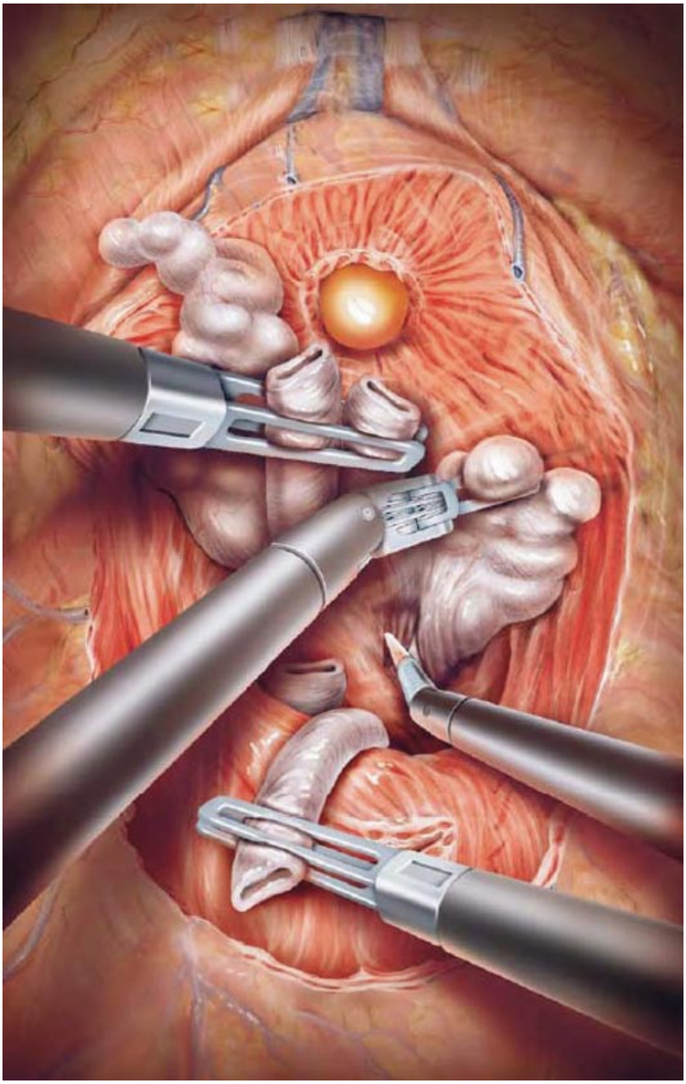


Fig. 8.8 Dissection of right seminal vesicle. (From [18])

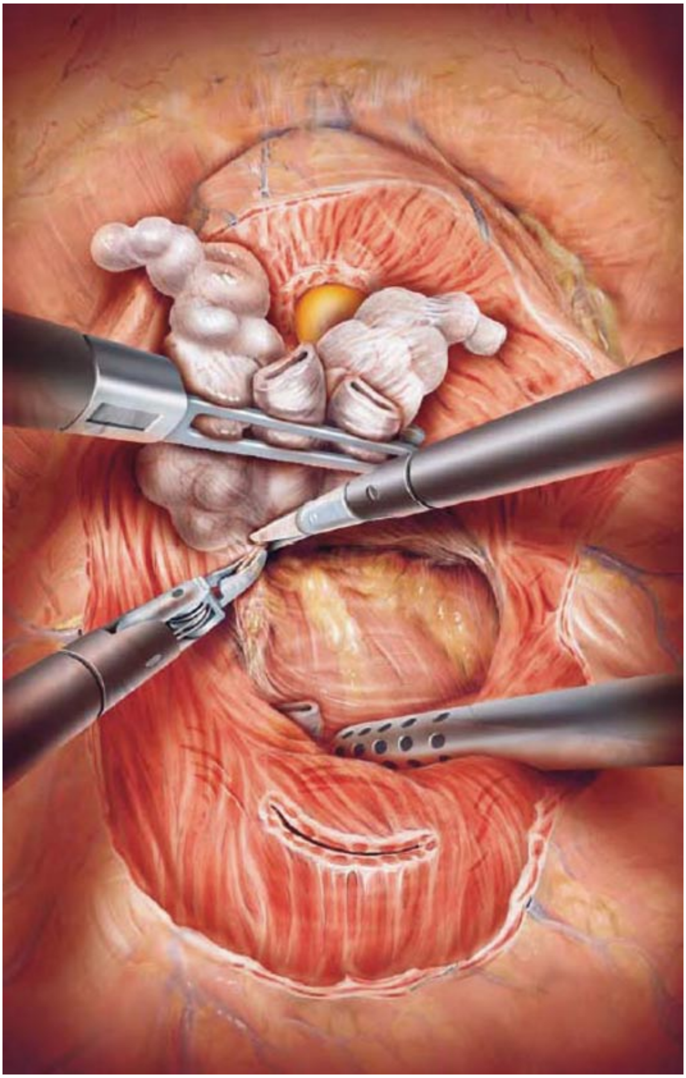


Fig. 8.9 Incision in posterior layer of Denonvillier's fascia to expose perirectal fat. (From [18])

The dissection is carried down to the apex of the prostate. This plane of dissection is extended laterally to expose the lateral pedicles of the prostate.

The base of the seminal vesicle is retracted superomedially by the assistant on the opposite side and the prostatic pedicle is delineated and divided. This pedicle lies anterior to the pelvic plexus and neurovascular bundle and includes only prostatic blood supply (Fig. 8.10). The pedicles are controlled by either clipping or individually coagulating the vessels by bipolar cauterization.

8.5 Nerve-sparing Technique: the "Veil of Aphrodite"

Although the classical description of the neurovascular bundles is that of two bundles of tissue that are located near the posterolateral surface of the prostate [6], there is accumulating evidence that this complex is variable. In some patients, rather than distinct neurovascular bundles, the cavernosal nerves form lattices or curtains that extend from the posterolateral to the anterolateral surface of the prostate [11–15]. In order to preserve these nerves, we [8] and several other surgeons [13, 16] have modified nerve-sparing techniques by incising the lateral prostatic fascia more anteriorly on the prostate. We termed this approach the "veil of Aphrodite" nerve-sparing technique. (Aphrodite is the Greek goddess of love who causes strong men to fight over her.) Subsequent to our description, others have described a "high anterior release, "curtain dissection," or "incremental nerve sparing."

In the "Veil procedure" we accomplish this through an antegrade approach. The dissection is set up by a full release of the prostate from the surface of the rectum, from the base of the prostate to the apex of the prostate. This posterior dissection occurs in a relatively avascular plane and should be carried out as far laterally as possible. With these maneuvers, the location of the neurovascular bundles and the prostatic pedicles can be clearly seen as pillars tethering the prostate posteriorly and laterally.

The prostatic pedicles can be isolated using the scissors and bipolar forceps and clipped using a Hemolock or metal clip and divided using the cold scissors. With release of the pedicles, the prostate becomes more mobile and can be grasped by the assistant and manipulated to demonstrate the plane between the prostate and the neurovascular tissue.

A plane between the prostatic capsule and the prostatic fascia is developed in a craniocaudal direction, starting at the base of the seminal vesicles. With appropriate countertraction provided by the assistants the surgeon is able to enter a plane between the prostatic fascia and the prostate. This plane is deep to the venous sinuses of Santorini's plexus. Careful sharp and blunt dissection of the neurovascular bundle and contiguous prostatic fascia is performed using the articulated "cold" scissors until the entire prostatic fascia up to the pubourethral ligament is mobilized in continuity. Care must be taken to control the plane of dissection using a proper mix of sharp and blunt dissection in order to ensure that the prostatic capsule is not breeched. This plane is mostly avascular except anteriorly where the fascia is fused with the puboprostatic ligament, and covers the dorsal venous plexus. When performed properly, curtains of periprostatic tissue hang from the pubourethral ligaments, and form the veil of Aphrodite (Fig. 8.11).

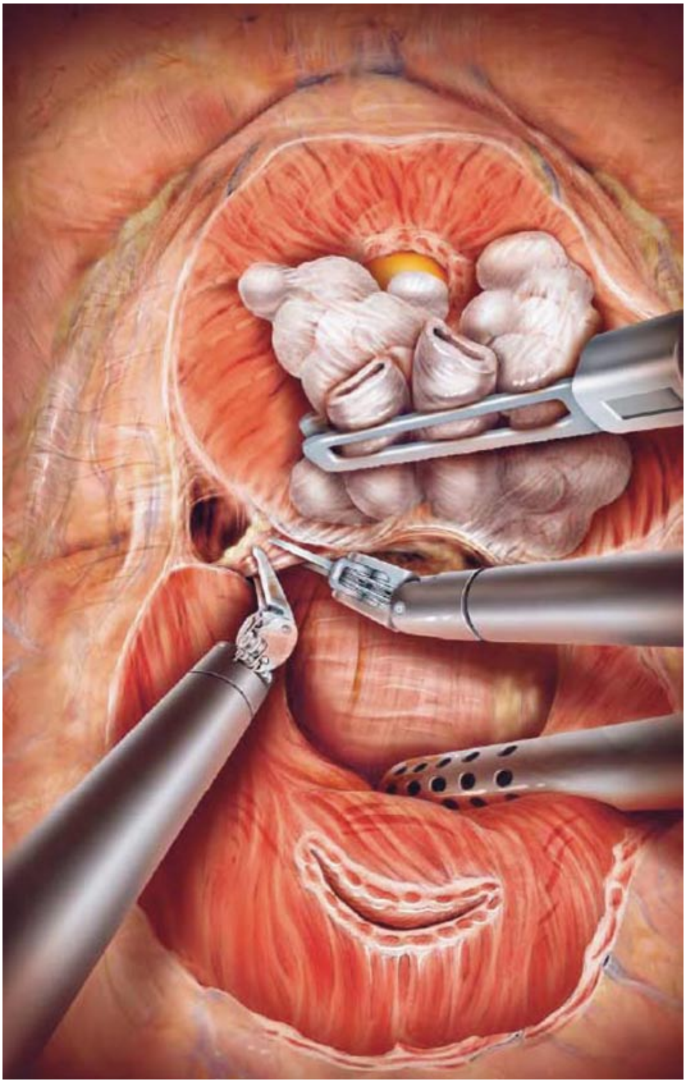


Fig. 8.10 Control of left prostatic pedicle. (From [18])

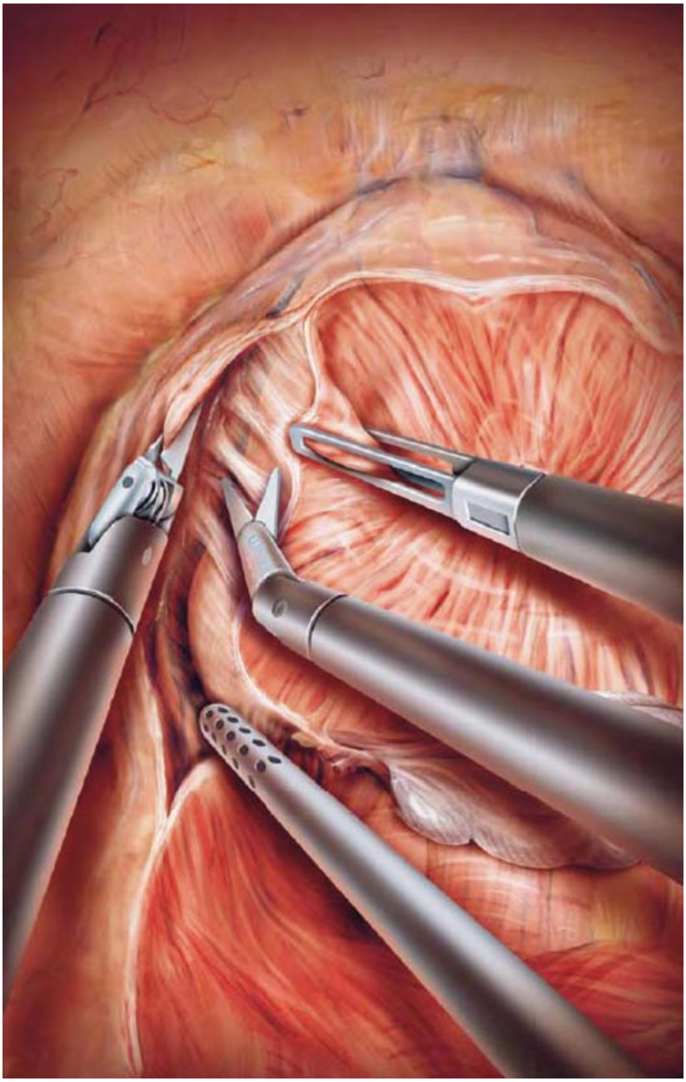


Fig. 8.11 Plane of dissection of the "veil of Aphrodite" nerve sparing. (From [18])

If this plane is difficult to enter at the prostatic base (as in patients with postbiopsy fibrosis), it may be advantageous to perform part of the dissection in a retrograde fashion. The plane of dissection can be entered on the anterolateral surface of the prostatic capsule at the 10- or 2 o'clock position. The dissection can be carried out proximally and distally to release the veil tissue. The plane can also be continued to the posterior surface of the prostate, fully releasing the bundle at the mid-prostate before releasing the prostatic pedicle.

8.5.1 Exposure of Prostatic Apex and Control of Dorsal Venous Complex

The prostatic apex is best visualized using the 0° lens. This is particularly useful in patients with an overhanging pubic symphysis. Once the lateral prostatic fascia is dissected off the prostatic apex, the right assistant retracts the prostate firmly to the patient's head. The puboprostatic ligament is incised with the cold scissors where it inserts into the apical prostatic notch (Fig. 8.12).

It is important not to skeletonize the urethra, as maintaining the fibrovascular support of the urethra intact hastens the return of continence. The cavernosal nerves are close to the urethra and are vulnerable to thermal or traction injury.

The urethra is then dissected into the prostatic notch and transected sharply 5 mm distal to the notch (Fig. 8.13). The freed specimen is placed in an Endopouch (Ethicon Endo-Surgery, Somerville, New Jersey).

The dorsal venous complex is controlled with an overrunning suture of 2-0 braided polyglactin on 17-mm tapercut needle.

Depending on the amount of oozing from the dorsal vein complex, control is done before or after urethral transection.

8.5.2 Urethrovesical Anastomosis

A running suture is used for the urethrovesical anastomosis. We use a minor modification of the technique described by van Velthoven [17]. One dyed and one undyed 7-in. 3-0 monofilament polyglecaprone-25 suture on 17 mm tapercut needles are tied back to back. The suture is now double-armed with a pledget of the knots in the middle. We start with dyed arm, on the posterior bladder wall at 4 o'clock position outside-in, continuing into the urethra at the corresponding site, inside-out. The dyed arm is run for two bites in the urethra and three in the bladder neck. The bladder is then cinched down to the urethra, with the right assistant "following" the suture (Fig. 8.14a). After the posterior urethral wall is approximated to the bladder neck in its entirety, the direction of the stitch is then changed to get passage of the needle from outside-in bladder to inside out. The suture is run clockwise up to 11 o'clock position, and handed to the left assistant to hold with gentle, approximating traction. The undyed arm is then run counterclockwise from 4 o'clock to 11 o'clock (Fig. 8.14b). During the placement of anastomotic sutures the left assistant moves the tip of urethral Foley in and out of the urethral stump to prevent suturing of the back wall of urethra. Both arms of the suture are tied to each other to complete the anastomosis.

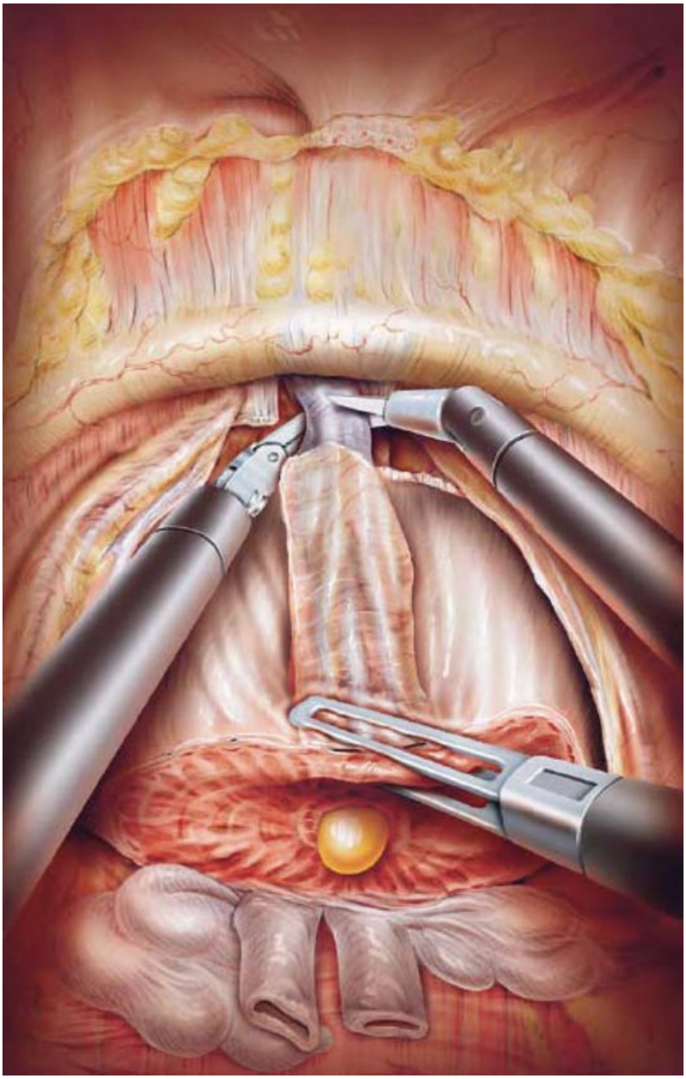


Fig. 8.12 Transection of puboprostatic ligaments and dorsal venous complex. (From [18])

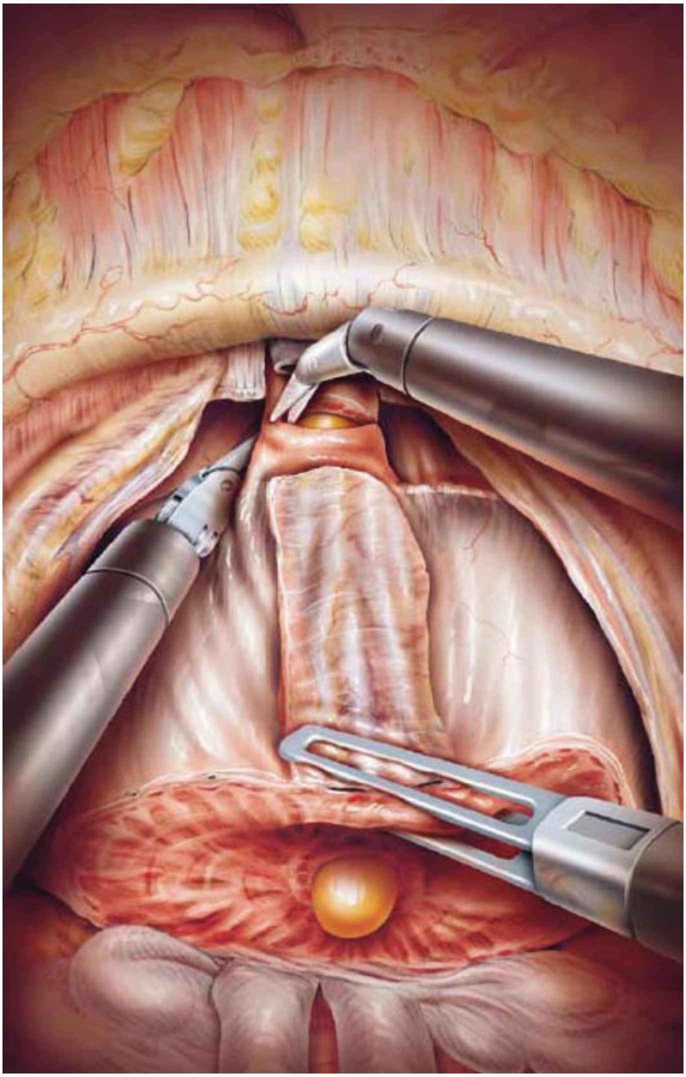
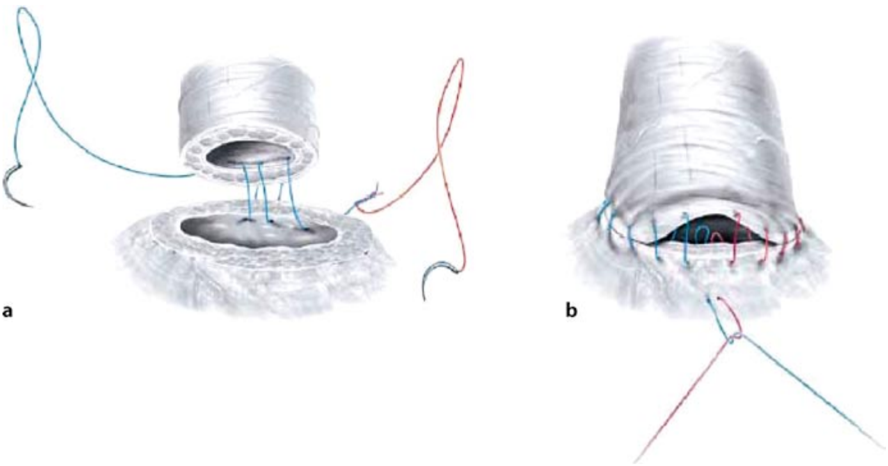


Fig. 8.13 Urethral transection. (From [18])



a b

Fig. 8.14a,b Urethrovesical anastomosis. (From [18])

A new 20-F Foley catheter is introduced and its balloon is inflated to 30 cc. The bladder is filled with 250 cc saline to test the integrity of the anastomosis.

8.5.3 Retrieval of Specimen and Completion of Surgery

A Jackson–Pratt drain is placed through left 5-mm port. The specimen is removed after enlarging the umbilical port incision as required. The incision is closed with interrupted sutures of 0 braided polyester. The skin is closed with subcuticular sutures.

8.5.4 Postoperative Care

In order to minimize the urine spillage into the operating field, intravenous fluids are restricted to a minimum during the surgery. Patients who are clinically dehydrated receive a 1000-ml bolus of intravenous fluid in recovery room. Once on the floor they start on a clear-liquid diet and advance to regular diet after a bowel movement. All patients are encouraged to ambulate within 4–6 h of arrival on the floor. The JP drain is removed on day 1 and patients are discharged within 24 h with an indwelling Foley catheter. The catheter is removed between days 4 and 7 under cystographic control.

8.6 Crossing Over the Learning Curve

Minimally invasive prostate cancer surgery has a steep learning curve [4]. The critical elements of starting a new program without compromising the quality of care are structured program, setup, and patient selection.

8.6.1 Structured Program

We have demonstrated the benefits of using a structured approach to initiate a robotic prostatectomy program [5]. The team of console- and patient-side surgeons learning this operation should observe 15–25 cases at a high-volume center. This team should remain consistent in their roles until they are over their learning curves. The robotic prostatectomy is a complex undertaking, and frequent changes in the surgical team hampers coordination of compromising speed and safety of the procedure. It is equally important to have an experienced mentor during the learning curve. The new surgeon on the team should be given responsibility in a graded fashion: observer, left-side assistant, right-side assistant, and console surgeon, respectively.

8.6.2 Setup

Providing a 3D display system to the assistants and other personnel in the operating room improves the coordination and the efficiency of the team. The new Da Vinci S system is smaller and has greater range of movements of its arm than the previous model. These features make Da Vinci S more forgiving in port-placement errors.

8.6.3 Patient Selection

It is very important to select easy operative candidates during the initial experience of the team. Criteria for selection of *ideal patients* for a new program are as follows:

1. Prostate size 30–40 g; large prostates are difficult to retract in limited pelvic space resulting in tough apical and nerve sparing dissection.
2. BMI 23–28; too small patient has less space on abdominal wall for port placement leading clashing of instruments during the procedure. In large and obese patients instruments may not reach to the depths of the pelvis.
3. No previous prostatic or abdominal surgery; peritoneal adhesions may pose difficulty in port placement and scarring around the prostate from previous surgery may obliterate the planes of dissection.
4. Preexisting erectile dysfunction and low-risk disease (PSA <10 ng/ml and Gleason score <7); minimize the risk of causing erectile dysfunction and leaving positive surgical margins during the early experience.
5. Minimal lower urinary tract symptoms (LUTS); patients with LUTS may have median lobe or intravesical lateral lobes making bladder neck dissection difficult.
6. Medically healthy – no COPD; patient should be fit enough to sustain the steep Trendelenberg's position and pneumoperitoneum for longer periods of operative time during the initial experience.

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Chapter

9 Robotic Assisted Radical Prostatectomy: the Apical Dissection

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Jamison Jaffe, Eric Barret,
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9.1 Introduction

The primary goal of robotic-assisted radical prostatectomy (RALP) is to completely remove the cancer and cure the patient of their carcinoma. Secondary goals of definitive therapy for prostate cancer include both the preservation of preoperative continence and potency. The apical dissection is one of the most crucial steps in the RALP. The dissection of the apex is the one part of this procedure in which the oncological outcome as well as the functional outcomes are in jeopardy if done inaccurately or incorrectly. The surgeon must clearly identify the apex of the prostate to avoid inadvertently entering the prostate and creating a positive surgical margin. The nerves are located in close proximity to the urethra and may be injured if not identified. Post-operative continence is also dependent on an accurate apical dissection. The rhabdosphincter should be clearly identified and a maximum functional urethral length should be maintained to prevent damage to these structures and to avoid postoperative incontinence. If the surgeon does not perform a meticulous dissection the "trifecta" of long-term cancer control, along with recovery of continence and sexual function will not be achieved [1].

The three-armed Da Vinci surgical system (Intuitive Surgical, Sunnyvale, Calif.) is utilized at our institution. We utilize an extraperitoneal approach. One bedside assistant trained in laparoscopy assists at the patient's left side. A 12-mm subumbilical trocar is used for the robotic camera. Two 8-mm robotic trocars are placed lateral to the rectus muscles half the distance from the umbilicus and the pubic bone. The assistant 10- and 5-mm trocars are placed in triangulation around the left robotic trocar (Fig. 9.1). A 0° lens is used throughout the entire procedure.

9.2 Preparation of the Apex

The apical dissection occurs after the prostate has been removed from the bladder and the dissection of the seminal vesicles and neurovascular bundles have been completed. The Maryland bipolar forceps in the robots left arm and curved articulating scissors in the robots right arm are utilized for this part of the dissection.

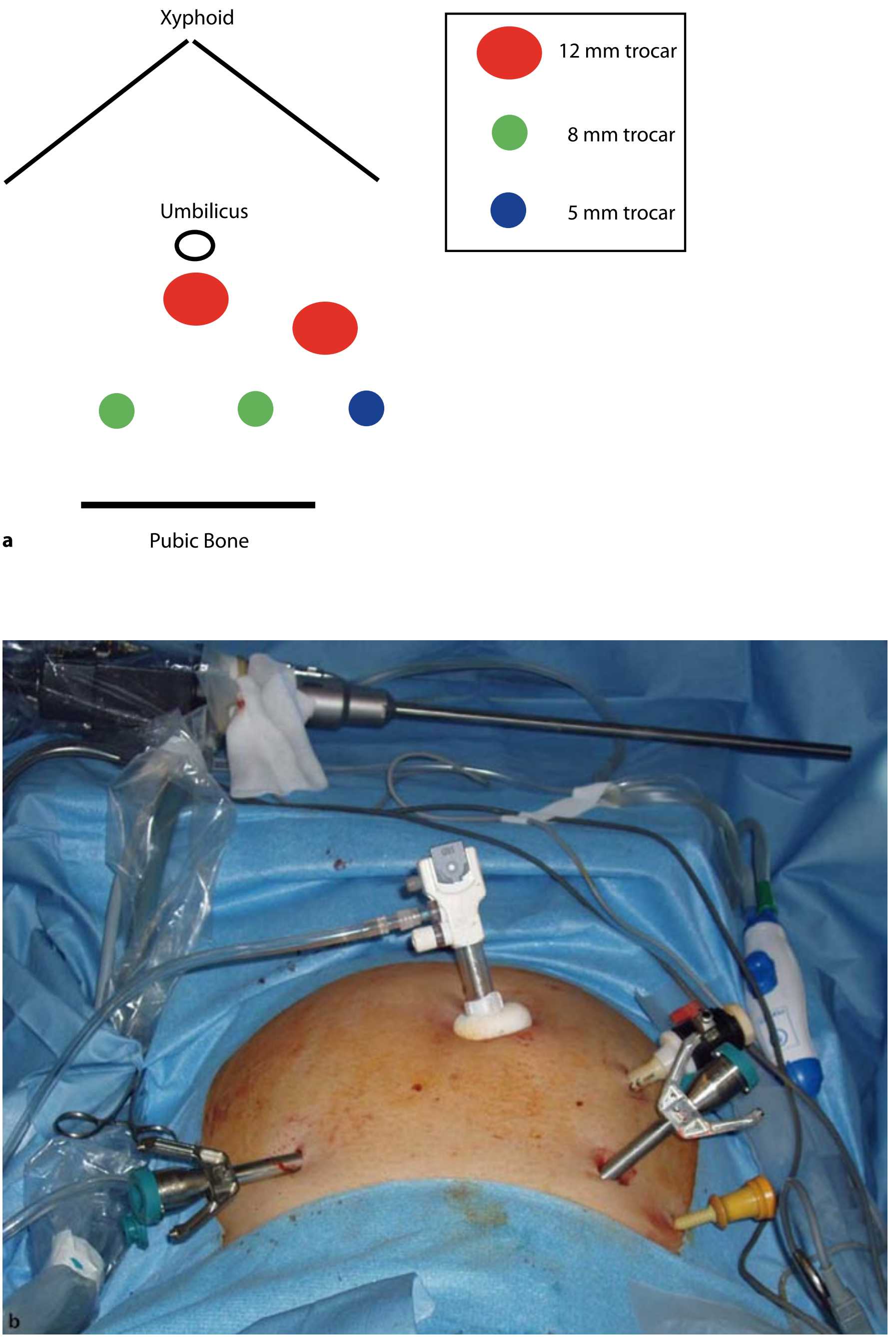

Fig. 9.1 **a** Trocar positions. **b** Trocar placement

Specific attention is required in case of:

1. Presence of an accessory pudendal artery which must be preserved (considering its potential in continence and potency recovery)
2. Anterior location of the prostatic tumor (risk of an anterior positive margin)

The initial step of the apical dissection is to complete the opening in the endopelvic fascia. The endopelvic fascia is entered at the level where it reflects over the pelvic wall; the fibers of levator ani muscle are gently pushed away in order to expose the lateral surface of the prostate; the incision is prolonged towards the prostatic apex to expose laterally the dorsal venous complex, the urethra, and the striated ureteral sphincter. The puboperinealis muscle (specific role in the urinary continence) which covers the urethra is dissected bluntly from the apex exposing the urethra [2]. At this step, dissection of urethra must be limited, with elective cauterization of small arterial and venous branches coming from neurovascular bundles and/or pudendal vessels.

Then, the puboprostatic ligaments will be exposed. The puboprostatic ligaments are an extension of the endopelvic fascia and a component of a urethral suspensory mechanism to the pubic symphysis [3]. Fibrofatty tissue overlying the anterior surface of the apex and distal part of the endopelvic fascia must be removed. Puboprostatic ligaments are incised closer to the prostate than to the pubic bone to decrease the risk of damaging the anchoring system of the urethra to the posterior part of the symphysis. Superficial dorsal vein must be controlled with electrocautery, not too far under

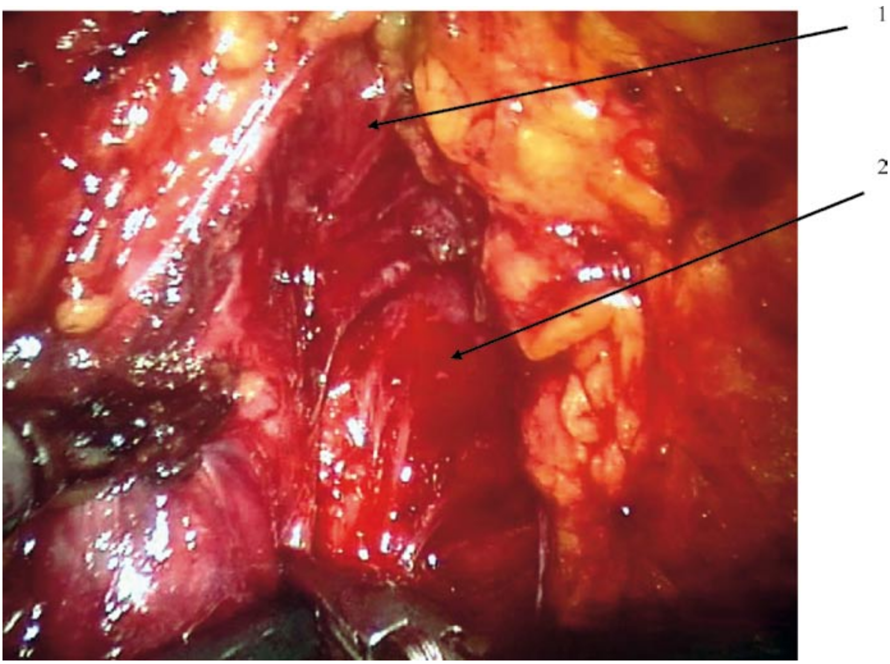

Fig. 9.2 Exposure of apex after transection of the puboprostatic ligaments. The external sphincter fibers (*1*) and the levator ani fibers (*2*) can be seen

the symphysis to avoid difficulties for complementary coagulation after section and retraction, in case of either.

The distal aspect of the levator ani muscle is then swept away from the prostatic apex, so both the striated sphincter fibers along with the dorsal venous complex are exposed (Fig. 9.2).

9.3 Dorsal Venous Complex

The dorsal venous complex (DVC) is approached once the complex has been isolated. The previous robotic instruments are replaced with needle drivers in both the right and left robotic arms. A 36-mm, 0-vicryl suture on a CT needle is passed underneath the DVC above the urethra. A second more superficial pass is then completed and then tied. (Fig. 9.3) Once the DVC is secured with the figure-of-eight suture, the robotic instruments are changed to the original set-up with the scissors in the right arm and the bipolar forceps in the left arm. The back bleeding is controlled with the bipolar electrocautery. After controlling the back bleeding, the assistant retracts down on the prostate using the vas deferens bilaterally to expose the space between the dorsal vein and the urethra. The surgeon then transects the DVC using the bipolar and scissors to expose

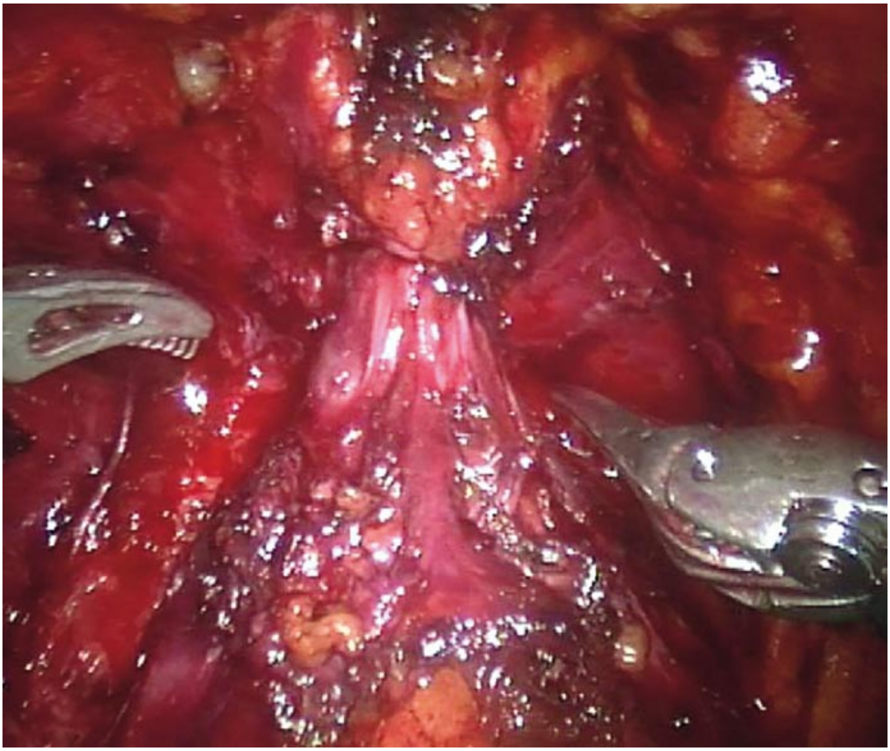

Fig. 9.3 Dorsal venous complex after being tied with 0 vicryl suture

the underlying urethra. The urethra is then isolated from the surrounding tissue prior to being transected. The dissection of the neurovascular bundle needs to be completed first (before transection of urethra) and pushed away laterally to avoid injury.

9.4 Completion of the Neurovascular Bundles

If the surgeon does not pay attention, the bundles which were spared earlier in the procedure can be easily transected at the apex. At this juncture, the surgeon is still operating with the bipolar in the left hand and the scissors in the right hand. The assistant grasps the prostate by the seminal vesicles and vas on one side and retracts the prostate to the opposite side to expose the neurovascular bundle as it enters adjacent to the urethra (Fig. 9.4). Once the assistant has the prostate in the proper position to expose the neurovascular bundles, the surgeon dissects the remaining bundle away from the prostatic apex and urethra [4-10].

9.5 Urethral Transection and Division of the Rectourethralis

Initially, the urethra was incised before freeing the apices from the neurovascular bundles. Presently, distal neurovascular pedicles dissection is performed before sectioning the urethra, considering that such procedure decreases the risk of positive apical margins; thus, the prostate is left hanging from the urethra. The use of a urethral benique is clearly helpful at this step in order to delineate the limits of the urethra. The surgeon asks the assistant to push down the benique to improve the vision of the anterior

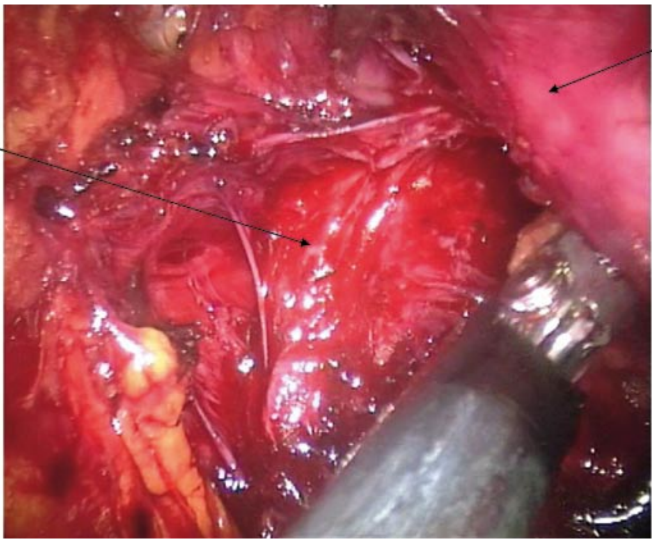

Fig. 9.4 The final release of the left neurovascular bundle (*NVB*) at the apex

surface of the apex, increasing also the urethral length. Sharp dissection of the tissue lateral to the apex and membranous urethra is performed, allowing precise dissection of the anterior surface of the urethra. Then, the assistant removes the benique partially until the level of the ligature of the dorsal venous complex and pulls it up. Dissection of the lateral limits of the urethra can be completed, preserving a sufficient functional urethral length without increasing the risk of positive apical margin. Then, the urethra can be safely opened anteriorly. The surgeon ensures that there is no apical tissue behind the urethra by passing an instrument posteriorly to ensure that the scissors do not cut into the posterior aspect of the apex and create a positive surgical margin. The ability to use the tip of EndoWrist (Intuitive Surgical, Sunnyvale, Calif.) round-tip scissors like a 90° dissector allows such a precise maneuver. After confirming the absence of prostatic tissue posterior to the apex, the urethra can be safely transected. The rectourethralis is all that remains once the urethra is cut. The surgeon needs to ensure that the rectum cannot be injured at this juncture of the procedure. The rectourethralis is cauterized with the bipolar and then cut with the scissors after confirming that the rectum is safe from inadvertent injury during this step. The prostate is then completely released. The surgeon should then confirm that hemostasis has been achieved prior to proceeding to the anastamosis [4-10].

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Chapter

10 Vesicourethral Anastomosis

Jean Joseph

10.1 Introduction

With the prostate removed, the vesicourethral anastomosis remains the most important step for the completion of the procedure. An improperly constructed anastomosis can easily obviate all the benefits of minimally invasiveness of robot-assisted radical prostatectomy. The preparation of the bladder neck and urethra during the removal of the prostate, discussed in previous chapters, are also critical in allowing a successful reconstruction. A meticulously constructed anastomosis is also necessary to shorten the recovery period and potentially contribute to diminished side effects of incontinence and erectile dysfunction. In this chapter a review of different techniques of vesicourethral anastomosis is presented.

The Da Vinci robot offers a number of advantages which have been described elsewhere in this book; however, none of these advantages are more useful than the improved ergonomics unknown to open or laparoscopic surgery. The anastomosis is one of the most complex aspects of the procedure which must be completed at the end of the case, when the surgical team is most tired. With the surgeon seated at the console, with head and forearm rested comfortably, fatigue factors become lesser issues that could potentially complicate the procedure. Using the Da Vinci robot, the surgeon benefits from the improved visualization, increased dexterity, and additional range of motion. Using standard laparoscopic equipment without these benefits, anastomotic times well over an hour have been reported for novice laparoscopists. The robot is generally touted for rendering laparoscopic suturing easy. When compared with laparoscopic nephrectomy, the requirement for laparoscopic suturing during laparoscopic prostatectomy may have been one factor responsible for the slower adoption of the latter by urologists.

There are three types of vesicourethral anastomosis that have been described: (a) interrupted; (b) running or continuous; and (c) semicontinuous.

10.2 Semicontinuous Suturing

At our institution we use a semicontinuous suturing technique (Fig. 10.1). Throughout the entire procedure a zero degree lens without scaling is used including the vesicourethral anastomosis. Two 2-0 Polygalactin sutures on and RB-1 needle (Ethicon, Norderstedt, Germany) are used. This needle is small and allows full rotation in very tight spaces. An UR-6 needle can also be used but can rotate excessively, burying the

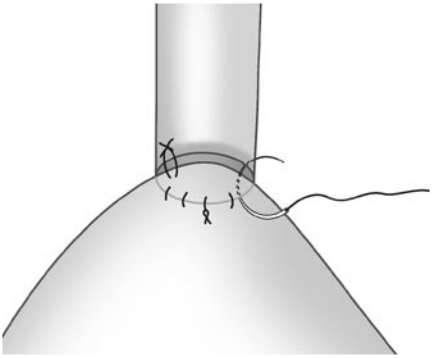

Fig. 10.1 View of semi-continuous suture technique. Posterior suture line is completed and tied. The needle is seen starting the anterior line

tip into the tissues, given the additional rotation provided by the wristed instruments. The sutures are cut to about one and a half the trocar length. They are inserted through the abdominal cavity or extraperitoneal space, via a 10-mm assistant port. The needles are pulled into the working space after removal of the passing instrument to avoid entrapment in the trocar and subsequent detachment of the suture. The needles can be placed through a 5-mm port, but with a higher risk of suture dislodgement, and subsequent straightening of the needle given the smaller port diameter. We also use the 10-mm larger port for placement of the specimen retrieval bag, and for placement of assistant's instruments during the earlier phases of the procedure. Two running sutures are used for the entire anastomosis, one anterior and the other posterior. The first suture is placed at the 5 o'clock position in the urethra and is tied to the corresponding position at the bladder neck. This suture is carried out in a clockwise direction approximating the bladder neck to the urethral mucosa ending at the 11 o'clock position. The initial needle starts in the urethral lumen to obtain adequate urethral tissue, and the knot is placed either inside or outside the bladder. These sutures are absorbable and dissolve quickly, making the location of the knot inconsequential.

The posterior suture line must be completely secure and all areas of suture looseness must be eliminated to prevent urine leakage. This area is inaccessible once the anterior anastomotic line suturing is begun. Three to five passes are generally necessary between the 5 and 7 o'clock positions to bring the posterior bladder neck in continuity with the urethra. The location of the Da Vinci surgical cart makes access to the patient's penis difficult to maneuver a rigid urethral sound; the latter is also potentially traumatic, causing us to prefer the soft Foley catheter used initially for bladder drainage as a urethral guide. Proper coordination is necessary between the surgeon at the console and the bedside assistant to avoid suturing the catheter in place. The Foley catheter is withdrawn as the surgeon advances the needle in the urethra. When the sutures are placed correctly, the Foley catheter is seen coursing easily into the bladder. With poor approximation, the catheter may enter in the posterior bladder neck. This can be corrected if detected immediately. Following completion of the posterior suture line, the anterior aspect of the anastomosis is carried out starting from the 5 to the 11 o'clock position in a counterclockwise direction, using the second suture. The first pass is made through the bladder (outside in) and into the corresponding position of the urethra (inside out) with the knot placed outside of the anastomosis. Six to eight passes may be necessary. Prior to tying the anterior suture at the 11 o'clock position,

a new Foley catheter (20 F) is inserted into the bladder under direct vision. Once the sutures are tied, the balloon is inflated to 30 cc. The bladder is irrigated to remove clots and ensure proper distension. Influx of fluid with bladder distension indicates the presence of a leak. With a large influx of fluid, and absent bladder distension, improper catheter location must be ruled out. A total of 200 cc of saline is used to fill the bladder with the balloon of the catheter away from the anastomosis. Pulling the balloon to the bladder neck, or placing the catheter on traction, does not allow proper testing of the integrity of the anastomosis.

10.3 Continuous Suturing

The continuous suturing was described by van Velthoven and has been popularized in the robotic literature by the group at University of California at Irvine [5]. This anastomosis requires creation of a single intracorporeal knot. Two sutures are used for the anastomosis, but the first knot is tied outside, prior to insertion of the needles inside the abdominal cavity. Both needles are passed through the bladder neck (outside in), leaving the knot outside the bladder. Each needle is used to suture the bladder neck to the urethra in opposite directions, sequentially. The two sutures are run individually, one clockwise and the other counterclockwise. The two sutures are brought to the midline anteriorly where they are tied to each other. This method is often perceived as the fastest way to complete the vesicourethral anastomosis (Fig. 10 2). It has a number of shortcomings, however, which can lead to significant complications both intraoperatively and postoperatively. A piece of orthotopic vas deferens is often used to help anchor the 6 o'clock knot. The use of Lapra Tye has also been reported in this setting. There has not been a significant benefit shown using this technique over the less expensive orthotopic vas deferens alternative. As the posterior aspects of the anastomosis are completed on each side, the surgeon often pulls on the two sutures, parachuting the bladder neck to the posterior urethra. This can be associated with disruption of the urethral passes. Bladder neck approximation must be ensured with each pass to eliminate urethral disruption.

The circular anastomosis is associated with potential tissue ischemia which can lead to bladder neck contracture in the postoperative period. Tissue approximation is the goal as opposed to tissue tightness. An accordion-like tension can result from a circular running anastomosis, and must be avoided to lessen the risk of leakage.

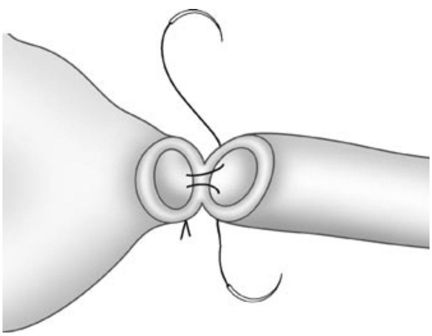

Fig. 10.2 Continuous suture technique with knot tied on posterior bladder neck

10.4 Interrupted Suturing

Most experienced laparoscopists use interrupted suturing (Fig. 10.3). The surgeon works with two needle holders, placing needles in both forehand and backhand positions as necessary. As many as 12 sutures have been found necessary to achieve good approximation, and a watertight anastomosis. Similar technique can be used with robotic technology. The integrity of the anastomosis rests on a multitude of sutures as opposed to a single knot. It ensures tissue approximation with each suture. Loosening of the suture line, which can be seen with the semicontinuous and continuous approaches, is avoided, limiting the potential for urinary leakage. This method of suturing, however, is lengthy and requires the use of several needles to carry out the procedure. Alternatively, a single needle on a long suture can be used, but this increases the complexity of the procedure, as the surgeon maneuvers an excessively long suture. The main advantage of this technique is that it eliminates the potential for radial force disruption inherent in approximating different tubular structures, of different consistency, and diameter.

Comparing single knot with interrupted techniques, no differences were reported by Poulakis et al. The anastomosis technique had no impact on extravasation or continence status. [6]. The running anastomosis had overall shorter operative times with a mean of 16 vs 24 min for the interrupted technique. Independent predictors noted for extravasation were integrity of the posterior suture line, and the width of the bladder neck opening.

The use of bladder neck traction using an extracorporeal suture has been found useful in the completion of the anastomosis [3]. Caudad traction on the bladder eases this step by relieving tension on the anastomosis, improving tissue apposition. This can potentially render this step much easier for novice surgeons. In our experience perineal pressure can also help achieve this, particularly with a severely retracted urethral stump.

The use of Bio Glue to reinforce the vesicourethral anastomosis has been tested in a porcine model but was found to be of no benefit. The addition of the glue increases the length of the procedure but did not contribute to the quality of the anastomosis [1]. To date, no large studies have been reported using this substance in humans.

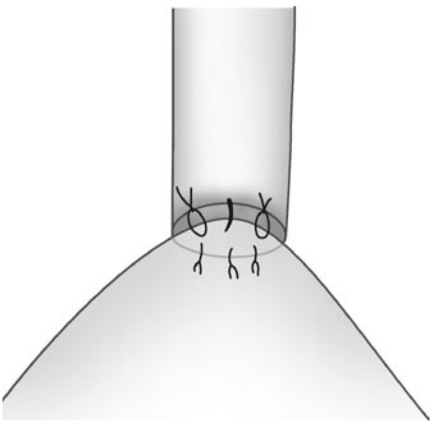

Fig. 10.3 View of interrupted suture technique

A novel method was recently described by Moran et al. [4], potentially overcoming the disadvantages to the continuous techniques described above [4]. A barbed bidirectional suture, 2-0 PDO (Quill Sutures, Research Triangle Park, N.C.), was used to perform robotic anastomosis, using an in-vitro microfiber synthetic model. Sutures were placed at predetermined sites and assessed for ease of use, radial force disruption, and security. The barbed bidirectional suture was found easy to use and capable of holding the tissues without knots or added tension. There was no radial disruption as is seen in the continuous technique. Cutting the suture did not lead to anastomotic disruption. This suture, however, has not been used in the urinary tract.

The semicontinuous technique is our preferred approach. It allows completion of the anastomosis in a very time-efficient manner. It avoids reliance on a single suture line, which can be broken leading to complete anastomotic disruption. Regardless of the techniques utilized, absorbable suture is the rule to avoid urinary stone formation along a residual suture line. Mucosa-to-mucosa apposition under tension-free conditions is a must to avoid potential complications. Whether an extraperitoneal or a transperitoneal approach, we found a lesser Trendelenburg position, and decreasing the intraabdominal pressure to about 8–10 mmHg may facilitate tissue apposition, resulting in a tension-free anastomosis. An exaggerated Trendelenburg may facilitate gravity retraction of the bladder but will, in the end, cause difficulty in carrying out the anastomosis.

The advantages of the EndoWrist technology are that it allows the surgeon to orient the needle in a variety of directions, to approach the tissue at the proper angle. The improved hand–eye coordination allows the surgeon to use both the left and right hands with equal ease, which is important in carrying out a delicate reconstructive procedure such as the vesicourethral anastomosis.

10.5 Complications

With robotic technology providing the surgeon with movements similar to those of the human wrist, the vesicourethral anastomosis can be carried out expeditiously with great ease. Complications associated with this step, however, can be associated with significant morbidity, lengthening the recovery period. These complications can be divided into intraoperative and postoperative.

10.5.1 Intraoperative

Blood loss can be a significant intraoperative problem that can complicate the completion of the anastomosis. While the pneumoperitoneum decreases small oozing from venous bleeding, large bleeders from the prostatic fossa need to be meticulously controlled to allow proper recognition of the anatomy, and adequate suture placement. Uncontrolled dorsal vein bleeding can result from dislodgement of the dorsal vein suture, or placement of the anterior sutures through the overlying dorsal vein bundle. Avoiding a large needle sweep, or using a small needle (e.g., RB-1), can generally avoid encompassing the dorsal vein in the anastomotic suture.

Urethral closure is possible without a proper guide for the needle entering the urethra. Two sides of the urethral wall can be caught with the suture, effectively closing

the urethral lumen. Difficult insertion of the Foley catheter should alert one to such possible complication. This can be avoided using a urethral sound or Foley catheter to help keep visualizing the urethral lumen. As described previously, the needle is inserted into the urethra as the sound or catheter is withdrawn.

Similar to urethral closure, the anastomotic needle can encompass more than one side of the bladder neck. This is more likely with closure of the anterior wall, with the tip of the needle poorly visualized as it courses away from the camera view.

Inadvertent injury can account for several other possible complications. Ureteral injury can occur both during the bladder neck dissection, and the vesicourethral anastomosis. During either step, visualization of the trigone, with efflux of urine from both ureters, is necessary to avoid such complication. To facilitate ureteral visualization we recommend the administration of intravenous indigo carmine (5 cc) when ureteral compromise is suspected. This can be administered shortly after the bladder neck dissection if the exact location of the ureters cannot be ascertained. It will obviate an unnecessary delay while the surgeon waits for renal excretion, or ureteral efflux of the blue dye. Absence of urine with proper hydration, or accumulation of urine outside of the bladder, should raise one's suspicion of a ureteral injury during the earlier parts of the procedure. With identification of an injury a ureteroneocystostomy should be done prior to the completion of the vesicourethral anastomosis. Intraoperative recognition of a ureteral injury is the most important aspect of management. One should take the necessary steps to ensure ureteral integrity prior to proceeding with placement of the posterior urethral sutures.

Rectal injury can occur with the posterior suture placement. This can be due to poor visualization of the bladder neck. It can also occur if a large needle is used to capture the posterior urethra. Sutures encompassing the adventitial layer of the rectal wall can be of no consequence. A suture, however, involving all layers of the rectum can potentially lead to devastating infectious complications, or rectovesical fistula.

Improper Foley placement can result from poor approximation of the posterior bladder neck to the posterior urethra (Fig. 10.4). Inflation of the balloon in that location can lead to further disruption of the bladder neck. When detected intraoperatively, a catheter guide can be used to push the catheter anteriorly through the bladder neck. In the postoperative period, flexible cystoscopy may be necessary to help visualize and access the bladder neck. Once identified, a guide wire can be inserted into the bladder over which a catheter is inserted. This complication is best avoided by adequately visualizing the entrance of the catheter into the bladder prior to the completion of the vesicourethral anastomosis. Irrigating the bladder under laparoscopic visualization help ensure proper positioning of the Foley catheter.

10.5.2 Postoperative

Bleeding can result in the postoperative period as a result of an anterior anastomotic suture placed through the dorsal vein. This is often not a problem intraoperatively, as the pneumoperitoneum serves to tamponade the site of the injury. With reversal of the pneumoperitoneum, this can present as brisk bleeding via the Foley catheter. If unsuspected, it may result in a significant pelvic hematoma compromising the healing process. Inflating the Foley balloon with about 30 cc of fluid, and placing the Foley catheter on traction, generally suffice to control such bleeding.

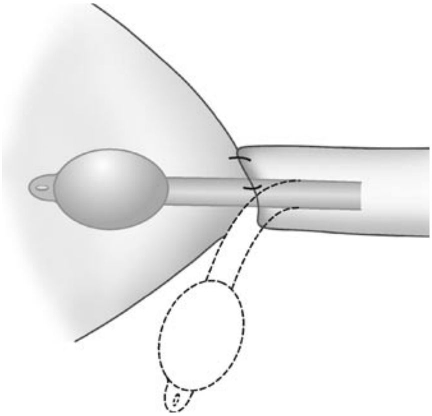

Fig. 10.4 View of Foley catheter through the vesicourethral anastomosis. *Dotted line* represents catheter improperly placed posterior to the bladder

Urine leakage can present as high drain output in the postoperative period. A high drain output with a low urinary catheter output often indicates urinary leakage. A high creatinine content of the drain fluid is diagnostic of this condition. When a drain is not placed, if the leak is significant it often presents as a urinoma, when the procedure is done via an extraperitoneal route. Urine ascites can ensue with the transperitoneal technique.

Urine leakage results from a poorly constructed, or disrupted, vesicourethral anastomosis. Inadequate suture placement can lead to poor tissue apposition with overriding tissue edges. This can cause leakage, which is generally self-limiting in nature and evident only with high pressure. Bladder irrigation can easily demonstrate breaches in the water tightness of the anastomosis, to help decide on corrective measures. With urethral catheter obstruction postoperatively, mild leakage at sites of poor tissue apposition can become significant, resulting in high urine output via the drain.

Prior to beginning the vesicourethral anastomosis, the bladder neck diameter must be assessed for the need of reconstruction. Following dissection of a very large median lobe, this can be necessary not only to properly size the lumen, but also to place the trigone in a more cephalad location relative to the edge of the bladder neck. The lumen of the bladder neck should closely approximate that of the urethral end, to allow a proper end-to-end anastomosis.

In the long term, a disrupted anastomosis can lead to urinary incontinence, the most feared and disabling complication associated with prostatectomy. With a well-constructed anastomosis, in our hands this complication in most men is becoming less common [2]. As many as a third of our patients achieve continence after removal of the catheter. In the setting of a large urine leak, the edges of the bladder neck and urethra are not in continuity to facilitate healing. With the two edges far from one another, the healing phase is prolonged and instead occurs via "secondary intention." Urine leakage is also associated with fibrosis of the bladder neck, limiting its compliance, impacting subsequent continence recovery.

Bladder neck contracture is another postoperative complication that can develop at any time during the postoperative period following catheter removal. Ischemia at the bladder neck and urethral edges is the likely culprit in the face of a tension-free mucosa-to-mucosa anastomosis. We recommend transecting the bladder neck and

urethra sharply without the use of cautery to avoid tissue ischemia. Management of this complication is beyond the scope of this chapter.

The visualization afforded by the robot allows proper dissection and delineation of the neurovascular bundles, decreasing the incidence of postoperative impotence; the latter, however, can result from poor anastomotic suture placement on the urethra. The proximity of the neurovascular bundles to the urethra places them at significant risk for injury. A poor urethral stump, retracting in the pelvic diaphragm with the pneumoperitoneum, can lead to this complication. The needle can be inadvertently placed through the bundle, as the surgeon attempts a large sweep through the urethra. Using a smaller needle and a urethral guide can help obviate such complication, with a previously well-preserved neurovascular bundle.

10.6 Conclusion

Robot-assisted prostatectomy is quickly becoming a preferred way to manage localized cancer of the prostate in men who are suitable surgical candidates. The technology offers great advantages. Its proper use in skilled hands remains the only way for men affected by prostate cancer to receive the greatest benefits. The vesicourethral anastomosis is a key reconstructive step of the procedure which the robot facilitates. The different techniques used offer both advantages and disadvantages. With continued technological improvements, and refinement of surgical skills, achievement of the triad of cancer control, preservation of continence, and erectile function will maintain radical prostatectomy as the most effective option for most men faced with this common disease.

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Chapter

Outcome Measures After Robot-assisted Laparoscopic Prostatectomy

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11

11.1 Introduction

Prostate cancer is the third most common cancer in men, with half a million new diagnosis worldwide yearly [56]. Prostate cancer accounts for approximately 10% of all male cancers and is the second most frequent cause of cancer death in men [38]. Radical retropubic prostatectomy (RRP) remains the gold standard treatment for organ-confined disease. Presently, most open radical prostatectomies are performed using the anatomical principles described by Walsh and Donker [76] and Walsh et al. [77] which have significantly reduced morbidity and mortality and improved postoperative continence and potency. To further reduce postoperative morbidity and improve convalescence, there is increasing interest in the application of laparoscopy in oncology. Laparoscopy has the potential for decreasing surgical morbidity, postoperative pain and narcotic use, blood loss, length of hospital stay, and improve cosmesis and convalescence from smaller incisions compared with open surgical approaches.

The first laparoscopic radical prostatectomy (LRP) was reported by Schuessler et al. [83] via a transperitoneal approach. Their initial experience with nine cases demonstrated no benefit compared with open radical prostatectomy with regard to length of hospital stay, convalescence, potency, continence, or tumor removal [67]. With further refinement of technique and advancements in instrumentation and technology, several institutions have now demonstrated decreased postoperative narcotic use, less blood loss, fewer minor complications, and comparable continence and potency outcomes with standard LRP [61, 63]; however, a pure LRP is technically challenging and demanding even in the hands of experienced laparoscopic surgeons limiting its widespread use. To help overcome the limitations of standard laparoscopy, robot surgical systems which use 3D viewing, articulating instruments with 7° of freedom, full-range-motion surgical arms, tremor reduction algorithms, and intuitive motions have been introduced. Originally developed for performing battlefield trauma operations with the surgeon controlling the instruments in a console from a safe distance [26], such systems have been adapted for medical use in civilian hospitals and are effective in cardiac surgery and other procedures [12, 14, 68].

Robot-assisted laparoscopic prostatectomy (RALP) has generated a lot of enthusiasm among surgeons and patients alike due to its minimally invasive nature, and its excellent short-term outcomes compared with the open and standard laparoscopic approach.

This chapter discusses operative, perioperative, quality of life, and oncological outcome measures with RALP.

11.2 Operative Results

11.2.1 Operative Time

Comparing operative times between RALP series is difficult due to reporting variability between centers. Some series report only the console time, others may include port placement and robot docking time, while others may or may not include the pelvic lymph node dissection. Furthermore, resident and fellow training may add to the operative time in academic centers. Mean operative times for most RALP series range from 141 to 450 min (see Table 11.2). As with any new procedure or technique, there is an inherent learning curve which can be operator dependent. Most centers report shorter operative times with increasing surgeon experience. Mikhail and colleagues [49] recently provided their experience with 200 RALP cases. The average operative time for their first 100 patients was 342 compared with 208 min for their last 100 cases. Patel et al. [54] described a similar trend in their initial 200 case experience with mean operative times of 202 min for their initial 50 cases vs 141 min in their last 50 cases. Similarly, Ahlering and associates [1] reported a mean operative time of 184 min in their last 10 cases vs an overall mean operative time of 207 min for the entire series.

An advantage of the Da Vinci surgical system is the ease in which surgeons without laparoscopic training can transfer their skills to the laparoscopic arena. A standard LRP is technically challenging and has a steep learning curve even in the hands of experienced laparoscopists. Menon et al. [45] showed that robot assistance enabled an experienced open surgeon to achieve operative times similar to those of an accomplished laparoscopist within 18 cases. Similarly, Ahlering and coworkers [1] demonstrated that an experienced open surgeon with no prior laparoscopic training was able to perform a RALP in less than 5 h within 10 cases (Fig. 11.1). The learning curve to 4-h proficiency was 12 cases with a subsequent mean operative time of 3.45 h thereafter [1]. This suggests that the learning curve for RALP is shorter than standard laparoscopy even when performed by a laparoscopic-naive open surgeon.

Comparing operative times between techniques (open, standard laparoscopic, RALP) is challenging due to reporting variability (Tables 11.1–11.3). Nonetheless, according to single institution series comparing their open vs robotic experience, there is no significant operative time differences between techniques [2, 71, 72].

11.2.2 Blood Loss and Transfusions

Reducing intraoperative blood loss has potential benefits for the patient, surgeon, and anesthesiologist. Less blood loss improves operative field visualization and logically should allow a more precise anatomical dissection. This is most important during criti-

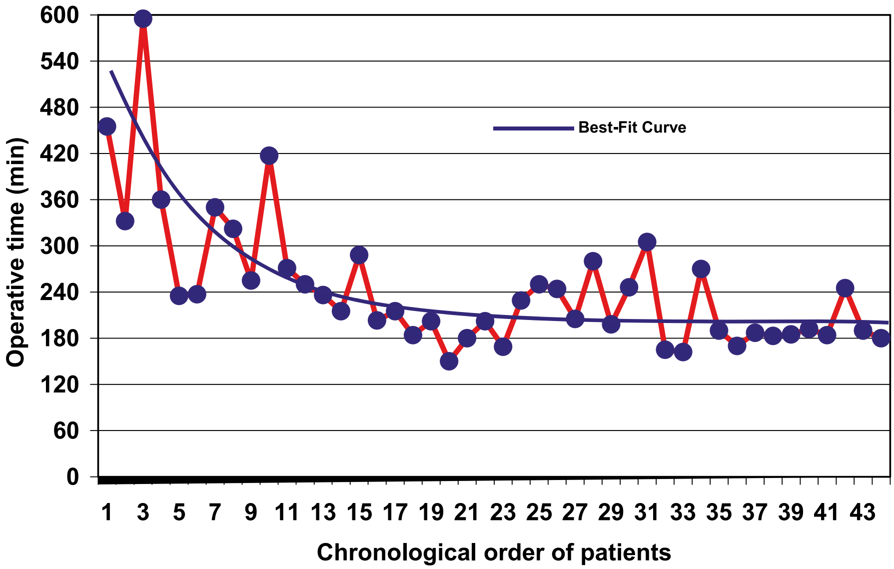

Fig. 11.1 Robotic-assisted radical prostatectomy experience at UCI (first 45 patients). (From [10])

cal steps of the operation when surgical imprecision can compromise cancer control or affect postoperative patient quality of life, particularly potency and continence. Less blood loss reduces the need for blood transfusion which carries the risk of hepatitis B and C or HIV infection, transfusion reaction, or anaphylaxis. A precise measure and comparison of estimated blood loss (EBL) during robotic or open prostatectomy is difficult due to the inherent subjectivity. Nonetheless, it follows logically that improved magnification (10×) should allow the surgeon to identity and control smaller bleeding vessels more readily. Furthermore, the pneumoperitoneum tampanodes bleeding venous channels that otherwise may continue to ooze during standard open surgery.

The reported EBL in larger robotic series ranges from 75 to 500 ml with most series reporting <200 ml (Table 11.1). Estimated blood loss in the RALP series compares favorably to both standard laparoscopic and open prostatectomy series (Tables 11.2, 11.3). The EBL should decrease further with surgeon experience. Menon and associates [46] noted an EBL of 391 ml in their first 40 robotic cases compared with 150 ml after 100 cases.

Although factors such as patient overall health, age, cardiac history, and surgeon practice patterns may vary between series and influence outcomes, blood transfusion is another surrogate marker of EBL. Transfusion rates in RALP series range from 0 to 12% (Table 11.1), with 6 series (>800 cases) reporting a 0% transfusion rate. To date, no open or standard laparoscopic prostatectomy series has reported a 0% transfusion rate. Tewari et al. [72] reported a 67% transfusion rate in their open series compared with 0% in their robotic group. Farnham and Smith [25] prospectively compared EBL, perioperative hematocrit, and transfusion requirements in patients undergoing RALP (n=176) vs RRP (n=103) by a single surgeon in a 14-month period. The EBL was 191 vs 664 ml, discharge hematocrit was 36.8 vs 32.8%, and the mean perioperative change in

Table 11.1 Robot-assisted laparoscopic prostatectomy series: functional and oncological outcomes. *RRP* radical retropubic. *PSM* positive surgical margins prostatectomy

Reference	Number	Age (years)	Operative time (h)	EBL (ml)	Transfusion rate (%)	PSM rate (%)	Length of stay (days)	Catheter removal (days)	Continence rate (%)	Erectile function (BNS/UNS)	Complication rates (%)	Conversion rate (%)	F/U (months)	PSA progression-free rate (<0.1 ng/ml)
[53]	5	58	3.7	800	n.a.	20	5.8	6.5	n.a.	n.a.	20	0	n.a.	n.a.
[12]	10	60.5	9	n.a.	10	30	n.a.	18	n.a.	n.a.	10	n.a.	n.a.	n.a.
[59]	33	68	7.5 [a]	n.a.	n.a.	18	n.a.	6.8	n.a.	n.a.	n.a.	0	n.a.	n.a.
[44, 45]	40	60.7	4.6	256	0	17.5	1.0	n.a.	n.a.	29/n.a.	5	0	6.5	n.a.
[46]	100	60	3.3	149	0	15	n.a.	n.a.	92	59	8	0	5.5	n.a.
[46]	200	59.9	2.6	153	0	6	1.2	7	96	64 (<60 years)	4	0	n.a.	n.a.
										38 (>60 years)				
[71]	100	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	58 [c]	n.a.	n.a.	n.a.	n.a.
[80]	81	63	4.2	300	12	22.2	n.a.	14	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
[17]	105	62	3	500	6	22	5.5	7	n.a.	n.a.	6.7	2	n.a.	n.a.
[3]	60	62.9	3.9 [b]	103	0	16.7	1.1	7	75 [c]	n.a.	6.7	0	n.a.	n.a.
[11]	300	60.3	2.96	109	0	n.a.	1.2	6.9	n.a.	n.a.	5.7	0	n.a.	n.a.
[54]	200	59.5	2.35	75	0	10.5	1.1	7.9	98	n.a.	n.a.	0	9.7	95
[18]	122	61.2	n.a.	n.a.	3	16	2	8.4	82	n.a.	16	0	n.a.	n.a.
[74]	150	60.8	3.2	n.a.	2.6	n.a.	3.4	n.a.	n.a.	n.a.	3.3	0	n.a.	n.a.

Table 11.1 (*continued*)

Reference	Number	Age (years)	Operative time (h)	EBL (ml)	Transfusion rate (%)	PSM rate (%)	Length of stay (days)	Catheter removal (days)	Continence rate (%)	Erectile function (BNS/UNS)	Complication rates (%)	Conversion rate (%)	F/U (months)	PSA progression-free rate (<0.1 ng/ml)
[39]	325	60	2.2	196	1	13	1	n.a.	96	46	9.6	0	n.a.	n.a.
[25]	176	59	n.a.	191	0.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.
[36]	322	62.1	3.1	250	1.6	n.a.	n.a.	n.a.	n.a.	n.a.	17.2	0.6	n.a.	n.a.
[49]	100	58.4	5.7	340	5	16	1.8	6.3	89	79/69	17	7	22	96

[a] Includes pelvic lymph node dissection in 27 of 33 patients
[b] Excludes robotic setup
[c] PSA<0.2 ng/ml
[d] Progression-free survival rate at 3 years

Table 11.2 Laparoscopic radical prostatectomy series (non-robotic): functional and oncological outcomes. *RRP* radical retropubic prostatectomy. *n.a.* not applicable, *EBL* estimated blood loss

Reference	Number	Age (years)	Operative time (h)	EBL (ml)	Transfusion rate (%)	Overall margin positive rate (%)	Length of stay (days)	No. of days with catheter	Time of assessment from surgery (months)	Continence rate	Erectile function (BNS/UNS)	Complicaton rate total, major/minor (%)	Open conversion rate (%)	F/U (months)	PSA progression-free rate (%; <0.1 ng/ml)
[67]	9	65.6	9.4	580	n.a.	11.1	7.3	n.a.	26	66	50	33, 11.1/22.2	0	26	n.a.
[58]	2	60.5	4.9	500	50	50	2.5	14	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.
[75]	22	n.a.	6.7	490	31	23	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	23	n.a.	n.a.
[70]	12	62.1	9.6	327	8	n.a.	2.4	n.a.	9.8	82	0	64	8	9.8	100
[82]	50	64.9	5.4	225	2	20	1.6	n.a.	6	76	4	20, 6/14	2	6.4	100
[63]	85	62.5	4.8[a]	522	n.a.	25.8	n.a.	n.a.	12	80.7	53.8/n.a.	n.a.	2.4	n.a.	91.4[j]
[59, 60]	180	64	4.5[b]	1230	31	16	10	7	12	97[j]	n.a.	18.9, 9/15	4.4	12	95
[61]	450	65	4.4[c]	n.a.	24.8	18.6	n.a.	7	18	95	n.a.	14.7	2.0	20.8	89[j]
[62]	500	64	n.a.	n.a.	n.a.	19	n.a.	7	18	95	n.a.	14.7	1.8	40	89[j]
[35]	134	64.8	4.7[d]	n.a.	3	25	6.1	4.8	12	86.2[k]	46/28[a,k]	8.9	0	12	89.6
[30]	120	64	4.0[e]	402	10	15	6.6	6.6	6	73.3[j]	5[j]/ n.a.[j]	25, 2.5/22.5	5.8	2.2	89
[31]	350	64	3.6[f]	354	5.7	15.4	6	5.8	12	85.5[j]	32[b,j]/n.a.	13.4	2	At least 12	92[j]
[32]	567	63.5	3.4[g]	380	4.9	n.a.	6.2	6.1	n.a.	n.a.	n.a.	17.1, 3.7/14.6	1.2	n.a.	n.a.
[73]	308	62.3	3.9[h]	193	1.6	21.1	7.5	7.8	12	92	38.5[c]	13.6	0	n.a.	n.a.

Table 11.2 (*continued*)

Reference	Number	Age (years)	Operative time (h)	EBL (ml)	Transfusion rate (%)	Overall margin positive rate (%)	Length of stay (days)	No. of days with catheter	Time of assessment from surgery (months)	Continence rate	Erectile function (BNS/UNS)	Complicaton rate total, major/minor (%)	Open conversion rate (%)	F/U (months)	PSA progression-free rate (%; <0.1 ng/ml)
[69]	70	63.4	2.6[c]	350	1.4	21.4	n.a.	8.2	6	90[g,j]	0[d]	n.a., 1.4/n.a.	0	At least 1	n.a.
[34]	26	70	7.5	850	100	n.a.	n.a.	9	6	100	14[e]	15.4	0	4	100
[2002]	70	60.8	4.6	449	5.75	11.4	2.5	7	At least 3 m	70.6	n.a.	20, 7.1/12.9	1.4	3 m	n.a.
[65]	235	63.5	4.4	n.a.	2	20.6	6.8	5.7	n.a.	n.a.	n.a.	15	0	36	86.2[j]
[22]	100	62.2	4.0	313	3.0	16	4.2	n.a.	12	90	62/n.a.	8, 6/2	1.0	At least 3	100
[33]	1000	63	n.a.	n.a.	n.a.	19.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	12	90.5[k]
[64]	600	62	2.9[i]	380	1.2	17.7	6.3	7.6	12	84[j]	64[f,j]	11.2, 2/9.2	0.2	12	n.a.

[a] Includes pelvic lymph node dissection in 17 of 85 patients
[b] Includes pelvic lymph node dissection in 163 of 180 patients
[c] Includes pelvic lymph node dissection
[d] Includes pelvic lymph node dissection in 56 of 134 patients
[e] Includes pelvic lymph node dissection in 36 of 120 patients
[f] Includes pelvic lymph node dissection in 75 of 350 patients
[g] Includes pelvic lymph node dissection in 110 of 567 patients
[h] Includes pelvic lymph node dissection in 232 of 308 patients
[i] Includes pelvic lymph node dissection in 107 of 600 patients
[j] PSA <0.2 ng/ml
[k] Progression-free survival rate at 3 years

Table 11.3 Open radical retropubic prostatectomy series: functional and oncological outcomes. *BNS* bilateral nerve sparing, *UNS* unilateral nerve sparing

Institution	Number	Age (years)	EBL (ml)	Transfusion rate (%)	Length of stay (days)	Complicaton rate total, major/minor	Margin-positive rate	Follow-up (months)	Pad-free continence rate	Erectile function (BNS/UNS)	PSA progression-free rate (<0.2 ng/ml)
Johns Hopkins (2000)	64	57	n.a.	n.a.	n.a.	n.a.	1.5	18	93 [d]	86 [a,d]	n.a.
Johns Hopkins (2001)	2404	59	n.a.	n.a.	n.a.	n.a.	n.a.	75	n.a.	n.a.	74
NYU (2001)	1000	60.3	819	9.7	2.3	7	19.9	n.a.	n.a.	n.a.	n.a.
NYU (2004)	621	58.7	n.a.	n.a.	n.a.	n.a.	n.a.	24	82.4 [d]	n.a.	n.a.
Washington University (1994)	1342	n.a.	n.a.	11.5	n.a.	7.4, 2.4/5.0	n.a.	n.a.	n.a.	n.a.	n.a.
Washington University (1999)	1870	63	n.a.	n.a.	n.a.	10	n.a.	18	92	68/47	n.a.
Washington University (2004)	3477	61	n.a.	n.a.	n.a.	9		18	93		n.a.
Mayo Clinic (1994)	3170	66	600–1030	5–31	n.a.	n.a.	24	60	n.a.	n.a.	52 at 10 years
Baylor (2002)	1000	62.9	n.a.	n.a.	n.a.	n.a.	12.8	53.2	n.a.	n.a.	75 (<0.4 ng/ml)
Baylor (1997)	472	62.2	n.a.	28.6	6.2	27.8, 9.8/18.0	n.a.	n.a.	n.a.	n.a.	n.a.
Baylor (2000)	314	60.5	n.a.	n.a.	n.a.	n.a.	n.a.	25.4	n.a.	70/26 [b]	n.a.
Baylor (1996)	581	63	800	n.a.	n.a.	n.a.	n.a.	24	91	n.a.	n.a.
Columbia University (1998)	480	62.6	n.a.	n.a.	n.a.	n.a.	n.a.	39.6	91.8 [e]	n.a.	n.a.
Mayo Clinic, Jacksonville (2000)	325	66	750	22	4.2	n.a.	18	50	n.a.	47 [c]	n.a.

Table 11.3 (*continued*)

Institution	Number	Age (years)	EBL (ml)	Transfusion rate (%)	Length of stay (days)	Complicaton rate total, major/minor	Margin-positive rate	Follow-up (months)	Pad-free continence rate	Erectile function (BNS/UNS)	PSA progression-free rate (<0.2 ng/ml)
Henri Mondor (2002)	147	65.1	n.a.	38	15.2	n.a.	31.7	54	n.a.	n.a.	n.a.
Armed Forces, multi-institutional (2001)	190	63.7	1575	n.a.	n.a.	n.a.	39.5	41.4	69.9	8.9 [c]	77.1
Armed Forces, multi-institutional (2001)	190	62.2	802	n.a.	n.a.	n.a.	43.1	41.1	74.8	8.2 [c]	72.4
Henri Mondor (2002)	119	64.6	n.a.	19	8.5	n.a.	18.5	46.8	n.a.	n.a.	n.a.
Tulane University (2003)	25	n.a.	350	n.a.	0.7	n.a.	n.a.	12	n.a.	41	n.a.

[a] 89% of men underwent bilateral nerve-sparing procedure

[b] Men age 60 years or younger; for 60.1–65 years: 49/15%; for age >65 years: 43/13%

[c] Nerve-sparing status unknown

[d] Assessed with validated patient questionnaire

[e] Assessed with non-validated retrospective questionnaire

hematocrit was 8.0 vs 10.7% for the RALP and RRP groups, respectively. Three patients in the RRP group (2.9%) and one (0.5%) in the RALP group required blood transfusion. In our experience in over 500 cases, we have had no intraoperative transfusions and just 2 patients (0.4%) required postoperative transfusions: one secondary to bleeding from a vessel at the tip of the seminal vesicle and the other due to a port-site bleeding.

11.2.3 Peri-operative Complications

As with open surgery, RALP complications are influenced by surgeon experience and occur more readily during the learning curve. Minor and major complication rates with open, standard laparoscopic, and robot-assisted prostatectomy are listed on Tables 11.1–11.3. As not all complications are reported, comparisons between institutions are difficult. Nonetheless, the complication rates appear to be less in the robotic series [9, 10, 20, 38, 42].

A recent multi-institutional study by Ahlering et al. [6] evaluated perioperative and late complications in 1130 RALPs. Overall complication rate ranged from 8.8 to 13.9%, with an 11.3% series average. There were no mortalities and only one conversion to open was reported. Overall there were 17 *major complications* (1.5%): 6 rectal injuries (0.5%); 5 PE (0.4%); 3 bleeding (0.3%); 2 DVT (0.2%); and 1 myocardial infarction. There were 81 *minor complications* (7.2%): 21 anastomotic disruptions (1.9%); 19 clotting/urinary retention (1.7%); 13 acute urinary retention (1%); 11 ileus (1%); 3 blood transfusions (0.3%); 2 wound infections; 1 urinoma; and 11 others (1%). There were 30 *late complications* (2.6%): 16 fossa strictures (1.4%); 7 incarcerated/incisional hernias (0.6%); 5 anastomotic strictures (0.4%); and 2 lymphoceles (0.2%). Major perioperative complications dropped significantly to <0.7% when surgeon experience exceeded 200 cases. The high incidence of fossa strictures in the early experience with RALP has been suggested to be an iatrogenic effect of using large Foley catheters (24 vs an 18 F) during stapling of the DVC (Yee et al., in press). In summary, Ahlering and colleagues [6] combined outcomes of 1130 cases demonstrate that RALP has acceptable low complication rates, and a very low operative mortality.

El-Hakim et al. [24] and Ahlering [7] described similar low complication rates in their literature review of RALP series in academic institutions. Conversion rate to open was 1.1%, while blood transfusion rate was 0.3%. Minor complications occurred in 4.55% of cases, and included urinary tract infections, anastomotic leaks, ileus, and port-site bleeding. Major complications occurred in 3.75% of cases, including deep venous thrombosis, pulmonary emboli, obturator nerve injury, anastomotic disruption, delayed bleeding, and wound dehiscence. Similarly, in a community series of 200 consecutive RALPs, Patel and associates [54] also noted a low complication rate. Baseline patient characteristics were similar to those of other reported series. There were no blood transfusions or conversions to open. Complications (2%) included 2 rectal injuries, 1 pelvic hematoma, and 1 bladder neck contracture.

11.2.4 Convalescence

The length of hospital stay (LOS) is often used as an instrument to measure recovery as it generally correlates with the patient's time to return to basic activities. The reported

LOS from several open, standard laparoscopic and robot-assisted prostatectomy series are listed in Tables 11.1–11.3. Patel and associates [54] reported a LOS of 1.1 days with 95% of patients discharged on postoperative day 1. As LOS is also driven by other factors such as cultural differences, health care systems, patient socioeconomics, and surgeon practice patterns, it is difficult to compare LOS particularly between countries. In the United States most RALP series report a LOS of 0.96–1.2 days, while the average hospitalization after open RRP is between 2 and 3 days. Ahlering et al. [3] evaluated their single-surgeon open vs RALP experience. The LOS for their first 60 RALP cases was 1.08 days compared with 3.5 days for their open RRP group. Similarly, Tewari and colleagues [72] reported a mean LOS of 1.2 days following RALP, compared with 3.5 days for their open RRP group.

Whether a shorter hospital stay is truly advantageous to a quicker recovery remains to be determined; however, there are other clear advantages to an earlier hospital discharge including decreased risks of nosocomial infections, and decreased health care costs.

11.3 Oncological Control

11.3.1 Surgical Margins and PSA Recurrence

Regardless of surgical approach, the cornerstone oncological principle of radical prostatectomy is complete elimination of all cancer cells. Cancer control can be assessed by margin status of the surgical specimen and presence of biological recurrence. Reported positive surgical margins (PSMs) in laparoscopic series are comparable to open radical prostatectomy series (Tables 11.2, 11.3) [37, 81]. Walsh and colleagues [78] noted overall PSMs of 1.5%, while most other open prostatectomy centers range from 12.8 to 43.1%, with an overall average of 23% (Table 11.3). According to Wieder and Soloway [79], there is a wide frequency of PSMs in open prostatectomy series ranging from 0 to 77%, with an average of 36%. When stratified by stage, average PSMs were 17% for T2a disease, 36% for T2b, and 53% in T3 disease [79].

The overall positive surgical margin frequency in RALP series with at least 20 patients is similar to the open literature with a range of 6–22% (Table 11.1). For organ-confined disease (pT2), PSMs range from 4.5 to 10.6%, while for T3 disease they range from 20 to 47%.

Recently, a three-surgeon multi-institutional review by Ahlering et al. [7] provided pathological margin outcomes in 1130 combined RALPs. A PSM was strictly defined as cancer cells at any inked margin. Mean values for relevant clinical data from all three institutions were: age (60.6 years); preoperative PSA (7.0 ng/ml); clinical stage T1C (82%); T2 (16%); and T3 (2%). The combined mean PSMs were: overall 13.3%; pT2 5.2%; and pT3 37.6%. These margin rates compare favorably to large open radical retropubic prostatectomy series. Surgical experience was shown to further reduce PSMs. Following 150–200 cases, the positive margin rate improved, with an overall rate <10% and pT2 margin rate <5% [6–8].

The positive surgical margin rates are greatly subjective and not standardized to allow a qualitative comparison between all institutions. Caution is advised when interpreting these results as comparisons should only be performed after adjustment of relevant covariates. It has been shown that surgical margin status is affected by the

clinical stage, serum PSA, and biopsy Gleason score [52]. When assessing patients with PSA <10 ng/ml, investigators at Henri Mondor reported PSMs in 20.6%, which is less than their previous report of 25% when not restricting for PSA level [35, 65]. Similarly, when patients with favorable characteristics were considered (PSA <10 ng/ml, cT1c disease, and Gleason grade ≤7), Ahlering and colleagues [2, 3] showed a decrease in the overall positive surgical margin rate from 36 to 17%.

An important aspect of radical prostatectomy is the reduction of iatrogenic positive surgical margins in otherwise organ-confined disease. The goal of 0% PSMs in pT2 disease remains a technical challenge, but it represents a theoretical perfection of iatrogenic-free surgical technique. With surgical experience and refinement of technique the frequency of PSMs should decrease. Ahlering and colleagues [2, 3] provided several technical points to aid in the apical dissection and minimize the risk of positive surgical margins: removal of all fat overlying the dorsal venous complex (DVC) and prostate; division of the puboprostatic ligaments; dissection of the levator fibers to expose and increase the DVC length; and division of the DVC using a laparoscopic vascular stapler. With implementation of these techniques, Ahlering and coworkers [2, 3] reduced their overall PSMs from 36 to 16.7% and reduced pT2 PSMs from 27.3 to 4.7%.

Ahlering and associates [2, 3] continue to refine meticulous apical dissection in an attempt to further reduce PSMs at the apex. Borin and Ahlering [13] showed that a more aggressive urethral resection resulted in marked reduction in overall PSMs without significantly affecting time to, or overall, continence. Evaluation of 200 single-surgeon consecutive cases (group 1) revealed that 75% of PSMs occurred at the apex. Assessment of visual cues for urethral length demonstrated that patients with very short urethral stumps requiring perineal pressure during the vesico-urethral anastomosis had equivalent time to continence and overall continence rates compared with patients with readily accessible long urethral stumps. Consequently, the point of urethral transection was altered to include 3–6 mm more of urethra. Time to continence and PSMs for the ensuing 100 cases (group 2) was prospectively followed to evaluate this technical modification. The overall PSM rate for group 1 was 17.6 vs 6% for group 2. In group 2 both pT2 and pT3/4 PSMs were further reduced with this new surgical approach (7.3 vs 2.4% and 50 vs 26.7%, respectively). Kaplan–Meier time-to-continence curves were not significantly different at 3 and 6 months with continence rates of 73 and 89% in group 1 vs 61 and 95% for group 2.

Assessment of long-term biological progression (PSA) after RALP is unknown at this time considering the relatively short follow-up of reported series thus far. Patel and his group [54] reported a 95% PSA progression free rate (<0.1 ng/ml) in 200 patients with a mean follow-up of 9.7 months. Similarly, Mikhail and colleagues [49] noted a 96% PSA progression free rate in 100 patients with a median follow-up of 12 months.

Initial short-term oncological outcomes with RALP are at least comparable to those of the open approach; however, in order for RALP to gain widespread acceptance as an alternative to the current gold standard, oncological outcomes cannot be compromised. Longer follow-up with larger numbers and standardized review methods will help confirm the efficacy of robot assistance in treating organ-confined prostate cancer.

11.4 Quality of Life

11.4.1 Continence

The return of urinary continence after radical prostatectomy is of paramount importance for patients' quality of life, and to the surgeon as a marker of operative technique. Continence rates of various open, standard laparoscopic, and robotic prostatectomy series are listed in Tables 11.1–11.3 [16, 21, 29, 40, 43]. Foote and Leach [28] noted a wide range (2.5–87%) of incontinence after open prostatectomy depending on the series and the type of incontinence considered. Although no standard definition of continence is used, most open contemporary series report ranges from 69.9 to 93% (Table 11.3). Walsh and coworkers [78] described pad-free continence rates of 54, 80, and 93% at 3, 6, and 12 months postoperative, respectively.

With ≥6 months follow-up, the urinary continence rates in RALP series range from 85 to 98%. In Patel et al.'s series [54] no-pad continence rates were 27% immediately after catheter removal, 47% at 1 month, 82% at 3 months, 89% at 6 months, 92% at 9 months, and 98% at 1 year. Likewise, Carlsson and Wiklund [15] described 90% pad-free continence rate at 3–6 months. Menon and associates [47] had similar results, with 96% pad-free continence rate at 3 months. In a single institution prospective comparative study, Tewari and colleagues [71] demonstrated a faster return to continence in the RALP group compared with the open RRP group (50% continence rate at 44 vs 160 days, respectively). In Ahlering et al.'s [1] initial experience of 185 RALPs, 33% were pad-free at 1 week after catheter removal, 50% were pad-free and 25% used a security pad at 1 month, and 80% were pad-free and 15% used a security pad or one pad per day at 3 months. The overall pad-free continence rate was 85% at 6 months, and 92% at 1 year.

We believe that the Da Vinci surgical system helps improve continence after surgery. Improved magnification (10×), tremor reduction, articulating instruments, and superb visualization from decreased blood loss should allow the surgeon to better identify and preserve the urethral sphincter and levator muscles, allow a more precise anatomical dissection of the prostate apex and the urethral stump, and assist in performing a watertight vesico-urethral anastomosis with mucosa-to-mucosa approximation; however, despite these technical advantages, there seems to be patient characteristics which can independently influence postoperative continence. We recently prospectively reviewed 100 men undergoing RALP, 19 men were obese (BMI >30) and 81 were non-obese (BMI < 30). The two groups were similar in age and pathological stage. Obese patients had significantly worse baseline urinary and sexual function, suffered more complications, recovered urinary function slower, and demonstrated a strong trend for delay in recovery time [4, 5].

Caution should be exercised when comparing continence rates between series, as there is no standard continence definition. The large discrepancy in continence rates between centers can be attributed to multiple variables including the use of different continence questionnaires, data collection and interpretation, patient and surgeon subjectivity, patient demographics and surgical experience. Self-administered questionnaires consistently report poorer outcomes compared with the clinical interview which many institutions use to report their results [50]. A standardized "no-pad" continence definition and more rigorous standardized data collection and interpreta-

tion methods with validated questionnaires will be instrumental in making accurate comparisons.

11.4.2 Potency

Preservation of sexual function has a significant impact on quality of life in men undergoing radical prostatectomy. Unfortunately, reporting variability makes true comparisons between series and operative technique a daunting task. Potency is influenced by preoperative patient characteristics with younger patients and higher baseline sexual function scores having better postoperative outcomes. Intraoperative factors such as number of neurovascular bundles (NVB) preserved, surgeon experience, and nerve injury also influence potency; therefore, to adequately compare potency rates between series, all of these factors must be accounted for. In addition, the use of validated questionnaires, such as the International Index of Erectile Function (IIEF) and the Sexual Health Inventory for Men (SHIM), are not uniformly used. Centers should stratify patients who are potent with and without the aid of medications or erectile dysfunction devices. In this regard, the use of validated questionnaires and standardized reporting algorithms are essential to the acquisition of accurate data which can then be used to correlate erectile function with operative technique.

Notwithstanding the foregoing information, potency rates after open RRP range from 8.2 to 86%, with higher volume centers obtaining better outcomes (Table 11.3) [57]. Walsh and coworkers [78] described potency rates of 38, 54, 73, and 86% at 1, 3, 12, and 18 months, respectively, following RRP. When stratified by age, 90% of men ≤60 years old were potent.

The mainstay to sexual function preservation is avoiding nerve transection followed by reduction of traumatic or thermal injury. Theoretically, with improved surgical field visibility from magnification (10×) and decreased blood loss, this should be more feasible with the Da Vinci surgical system. According to El-Hakim and Tewari's literature review [24] 49.5% of men were having intercourse and 79% had return of erections (with or without medical assistance) at an average of 7.7 months post RALP. A recent comprehensive review of RALP outcomes describes potency rates of 10–54% at 3 months and 20–97% at 12 months after nerve-sparing procedures [27]. Potency was defined as having sexual intercourse in five series, return of baseline sexual function in one series, and IIEF >21 in one series.

Menon and collaborators described an accessory lattice of nerves on the ventral and lateral prostate fascia ("veil of Aphrodite") which they believe is important in erectile function [41, 66]. In a study of 58 patients, the "veil of Aphrodite" was preserved in 35 men vs 23 controls. At 1 year 97% of the "Veil" group had erections strong enough for intercourse vs 74% of the controls [48].

Techniques such as bipolar electrocautery, harmonic scalpel, and ligasure have been introduced in an attempt to reduce thermal and stray electrical injury to the neurovascular bundles; however, in a dog model, Ong et al. [51] demonstrated significant decreases in erectile response when using monopolar and bipolar hemostatic cautery in close proximity to the NVBs. Eichel and Ahlering [23] previously described their cautery-free, clip-free dissection of the cavernous nerves to decrease nerve injury during RALP and hence improve sexual function. Their current technique involves placing

bulldog clamps on the lateral pedicles prior to cautery-free, sharp dissection of the pedicles and the NVBs off the prostate. Although complete information regarding potency will require at least 2 years of follow-up, Ahlering and coworkers [4, 5] have already shown dramatic improvement over their previous technique using bipolar cautery to control the vascular pedicle: 43 vs 8% of men (≤65 years and preoperative IIEF-5 of 22–25) had return of erectile function with the cautery-free technique at 3 months with or without 5-PDE inhibitors. Additionally, only 18% of patients with the cautery-free technique failed to have partial erections compared with 68% in the bipolar group. Since their initial report with 23 patients, Ahlering and his team [6] have updated their series to include 55 men of 150 consecutive cases. Results with the cautery-free technique remain stable with 42% (vs 8.3%) of men having return of sexual function within 3 months. Of the initial 55 patients, 34 now have 9-month follow-up data. The rate of erections adequate for vaginal penetration is approximately 80% with an average IIEF-5 of 18.9. As noted in Table 11.4, successful "vaginal penetration" is accompanied with more global sexual satisfaction. At 3 months, potent men had an average IIEF-5 of 17.6 (range 12–25) compared with 2.3 (range 1–7) in impotent men.

In summary, regardless of the specific surgical technique used to preserve the NVBs, to help maintain sexual function, all forms of electrocautery should be avoided in the vicinity of the nerves.

Table 11.4 Comparison of potency outcomes at 3 months, group 1 (cautery-free technique) vs group 2 (bipolar cautery). (From [5]). *SHIM* Sexual Health Inventory for Men, *CFT* cautery-free technique

Clinical factor (mean)	Initial (CFT) [b]	Group 1 (CFT)	Group 2 (bipolar)	Significance (p)
No. of patients	23	55	36	
Age (years)	55.7 (48–65)	56.7 (48–65)	56.5 (43–65)	n.s.
Preoperative SHIM [a]	24.3	24.4 (22–25)	24.3 (22–25)	n.s.
Nerve sparing				
Bilateral	17 (74)	42 (76)	28 (78)	n.s.
Unilateral	6 (26)	13 (24)	8 (22)	n.s.
Potency at 3 months	10 of 23 (43)	23 of 55 (42)	3 of 36 (8.3)	<0.001 [c]
All NS	8 of 17 (47)	17 of 42 (41)	3 of 28 (11)	0.008 [c]
Bilateral NS	2 of 6 (33)	6 of 13 (46)	0 of 8	0.05 [c]
Unilateral NS	15.7	17.6	17.0	n.s.
Potency at 9 months				
All NS	n.a.	26 of 34 (77)	6 of 30 (20)	<0.001 [b]
Bilateral NS	n.a.	20 of 25 (80)	5 of 22 (23)	<0.001 [c]
Unilateral NS	n.a.	6 of 9 (67)	1 of 8 (13)	0.05 [c]
AVE SHIM (potent men)	n.a.	18.9	14.4	n.s.

[a] AKA-IIEF-5

[b] Initial refers to the 23 men published previously (from [6])

[c] Fisher's exact *t*-test, two sided

11.5 Conclusion

With the introduction of the Da Vinci surgical system we are witnessing a paradigm shift from open to robotic radical prostatectomy as the procedure of choice at many centers worldwide. When compared with the open approach, early studies indicate that robotic prostatectomy has equal outcomes in short-term oncological control, potency and continence, and potentially favorable perioperative outcomes such as in blood loss and transfusion rates, minor complications, narcotic use, convalescence, and length of hospital stay; however, laparoscopic radical prostatectomy, whether performed using standard laparoscopic instruments or robotic assisted, is still in its infancy compared with open radical prostatectomy. Indeed, current results of experienced urological oncologists with open radical prostatectomy have set high standards in oncological and functional outcomes. In light of present-day open radical prostatectomy, in order to determine the true place of robotics in the surgical pantheon, validated questionnaires and analog assessment scales are essential to determine true functional results and need to be combined with careful long-term follow-up of oncological outcomes. Prospective cooperative interinstitutional studies of this nature are beginning to be reported by some centers.

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Chapter

12 Urinary Incontinence After Robotic-assisted Laparoscopic Radical Prostatectomy

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12.1 Introduction

Urinary incontinence following radical prostatectomy continues to be a significant problem despite improving surgical techniques. Robotic surgical techniques have the potential to improve urinary outcome measurements even more than their open predecessors. Improved visualization and precision of dissection with robotic technology offer a truly anatomic approach. The main purpose of this chapter is to summarize the status of urinary outcomes following robotic-assisted laparoscopic radical prostatectomy as well as to discuss the most current therapies used in the treatment of post-prostatectomy urinary incontinence. We also discuss the etiology of post-prostatectomy urinary incontinence, contributing risk factors, and the evaluation for incontinence as they are intimately related to prostatic surgical technique and incontinence interventions.

12.2 Incidence of Urinary Incontinence Following Radical Prostatectomy

The incidence of urinary incontinence following radical prostatectomy varies widely depending on the definition of incontinence used, era in which that data was collected, and variations of surgical technique. Open radical retropubic prostatectomy continues to be the gold standard by which all other techniques are compared. To examine the incidence of urinary incontinence following robotic-assisted laparoscopic radical prostatectomy, one must evaluate outcomes in relation to the established open standards. Table 12.1 summarizes representative reports of urinary continence rates following radical retropubic prostatectomy, radical perineal prostatectomy, laparoscopic radical prostatectomy, and robotic-assisted laparoscopic radical prostatectomy.

As open and laparoscopic techniques have been refined, two areas of urinary continence continue to improve, overall continence rate and time to continence. These are the two areas that may ultimately demonstrate the benefit of robotic technology in radical prostate surgery. When evaluating overall continence rate, it is most accurate to compare 2-year outcomes. Multiple long term reports have shown a relatively small

Table 12.1 Incidence of urinary incontinence following radical prostatectomy. NR not reported

Reference	Approach	No. of cases	Definition of continence	Continent at 3 months (%)	Continent at 6 months (%)	Continent at 12 months (%)	Continent at 24 months (%)
[18]	Retropubic	615	Protective pad/no pad	NR	NR	86	91
[33]	Retropubic	3477	No pads	NR	NR	NR	93% (at 18 months)
[36]	Retropubic	500	Protective pad/no pad	71	87	92	98
[64]	Perineal	90	No pads	56	82	93	NR
[65]	Perineal	704	No pads	71	85	94	NR
[66]	Laparoscopic	202	Protective pad/no pad	76	95	95	NR
[25]	Laparoscopic	550	No pads	NR	NR	83	91
[67]	Laparoscopic[a]	5824	No pads	NR	NR	84.9	NR
[47]	Robotic	200	No pads	82	89	98	NR
[40]	Robotic	1142	1 pad or less/day	NR	NR	95	NR
[68]	Robotic	325	No pads	93	96	NR	NR

[a] 7% robotic-assisted laparoscopic radical prostatectomy

but statistically significant improvement in continence from the 1-year to the 2-year follow-up [36, 50]. Time to continence is an outcome in radical prostatectomy series that has only been recently assessed with the development competing techniques.

In terms of overall continence, the 1-year continence rates in the largest robotic prostatectomy series have ranged from 95 to 98%, comparable to those reported in the largest and most contemporary open series that report an 86–92% continence rate [18, 36, 40, 47]. While these same open prostatectomy series report a 2-year continence rate of 91–98%, there is only a single large laparoscopic series that reports a 91% 2-year continence rate [25]. There are currently no robotic prostatectomy series that report 2-year continence rates. Despite comparable 1-year continence rates, there is room for improvement upon the open prostatectomy series if a reproducible and higher 2-year continence rate can be achieved.

Time to continence is an exciting and intriguing area of study when evaluating the various radical prostatectomy techniques. As seen in Table 12.1, there is certainly a suggestion that 3-month continence rates are higher in robotic series than in any other series. The difference in continence rates then narrows at the 6- and 12-month cutoffs. Whether or not robotic technology can improve on the time to continence after radical prostatectomy will need to be answered with a prospective randomized study.

12.3 Mechanism of Urinary Incontinence Following Radical Prostatectomy

To evaluate the mechanism of urinary incontinence following radical prostatectomy, we must rely on data obtained from open radical prostatectomy series. The three major causes of urinary incontinence following radical prostatectomy include bladder dysfunction, sphincteric dysfunction, and overflow incontinence, although a combination of mechanisms may be present.

Most evidence supports the idea that post-radical-prostatectomy urinary incontinence is primarily due to sphincteric dysfunction. While bladder dysfunction, either a loss of compliance or detrusor overactivity, may be present in a significant number of patients after radical prostatectomy, its influence on urinary incontinence is debated.

Several studies have urodynamically evaluated radical prostatectomy patients preoperatively and postoperatively. Majoros et al. evaluated their patients at a relatively early period postoperatively (2 months), and found sphincteric dysfunction in 90% of their incontinent patients. Isolated bladder dysfunction was rarely a cause of incontinence [38]. Kleinhans et al. [31] also urodynamically evaluated radical prostatectomy patients preoperatively and postoperatively (mean 7.6 months after surgery) and found that all incontinent patient had sphincteric weakness. A similar study by Pfister et al. [48] showed sphincteric dysfunction in 85% of incontinent patients at 3 months after surgery.

Ficazzola and Nitti [22] prospectively evaluated 60 incontinent patients with video urodynamics at least 6 months following radical retropubic prostatectomy. Sphincteric dysfunction was detected in 90% of patients. Forty-five percent of patients were found to have some component of bladder dysfunction, but only 3% of incontinent patients had bladder dysfunction alone. Leach et al. [34], evaluating incontinent patients following one of a variety of prostate procedures, reported that 56% of prostate cancer surgery patients had a "major component of high pressure bladder"; however, in this same group of patients, 82% had a component of sphincteric dysfunction. In addition, anticholinergic medication alone rarely cured a patient (4.7%).

The mechanism of post-radical-prostatectomy urinary incontinence has also been studied at the neuroanatomical level. These studies have been performed under the basic premise that the male rhabdosphincter is the primary source of continence in men following radical prostatectomy. It has long been known to be innervated by somatic branches of the pudendal nerve. Several groups have proposed additional neural pathways to the rhabdosphincter that could potentially be damaged during radical prostatectomy.

Narayan et al. [44] demonstrated a neural branch to the rhabdosphincter that arises from the dorsal nerve of the penis and enters the infraprostatic urethra at the 9- to 12 o'clock positions and 1- to 3 o'clock positions. While the dorsal nerve of the penis does arise from the pudendal nerve, its function is primarily sensory, and this branch to the rhabdosphincter may be a part of the urinary guarding reflex pathway [4]. Hollabaugh et al. [27] demonstrated that parasympathetic fibers arising from the inferior hypogastric plexus, continuing as the pelvic nerve, course inferolateral to penetrate the prostate and rhabdosphincter. These branches may also play a role in the urinary guarding reflex pathway but may also be damaged during radical prostatectomy. Further supporting this theory, John et al., measuring sensory thresholds at the bladder neck and proximal membranous urethra, showed a significantly higher sensory

threshold in incontinent patients after radical prostatectomy [29]. This suggests that potential damage to branches leading to the rhabdosphincter during radical prostatectomy decreases afferent nerve conduction that may be part of a reflex pathway.

Overflow incontinence secondary to anatomic obstruction from a urethrovesical anastamotic stricture is not uncommon. Its incidence has been reported to be 4.5 to 27.9% [26, 45, 50]. Sacco et al. additionally found a 33.8% stricture rate among their incontinent patients [50]. This evidence supports the multifactorial nature of incontinence following radical prostatectomy and supports the need for diligent and complete evaluation of all incontinent patients after radical prostatectomy.

12.4 Risk Factors for Urinary Incontinence Following Radical Prostatectomy

As with other components of radical prostatectomy, much of the evidence compiled to evaluate risk factors for urinary incontinence is based on open prostatectomy series. Numerous preoperative, perioperative, and postoperative risk factors have been evaluated, but only a select few have been reproducible in multiple reports. This is due to the usually small number of incontinent patients seen in any large series. While it seems there are multivariate analyses to refute any risk factor ever identified, the most commonly debated are age and nerve-sparing status. Other factors that may ultimately be found to influence continence rates after radical prostatectomy are previous prostatic surgery, certain urethral and prostatic measurements, presence of a urethrovesical anastamotic stricture, obesity, and preoperative International Index of Erectile Function 5 (IIEF 5) score.

Age was identified by Eastham et al. in a multivariate analysis to significantly influence continence rate and this finding was reproduced by others [18, 50]. Eastham et al. had reported that 15% of their patients were over the age of 69 years, which is a somewhat higher proportion than most series. Another multivariate analysis of 742 patients, including 26% of whom were older than 70 years did not find age to be a risk factor [61]. The two series, however, are truly not comparable. Eastham et al.'s group only had 10% non-nerve-sparing patients, whereas Wille et al.'s group [61] had approximately 90% non-nerve-sparing patients. Another recent report by Burkhard et al. did not demonstrate age to be significant risk factor in a series of 536 patients. While the proportion of non-nerve-sparing patients was similar to that of Eastham et al. [18], it is unclear how many patients there were over 70 years in the Burkhard group [7]. Interestingly, Twiss et al. showed that patients under the age of 50 years did not experience an improved continence rate, suggesting that the age threshold, if it exists, is beyond 50 years old [56]. Ultimately, the evidence suggests increasing rates of urinary incontinence with advancing age following radical prostatectomy, but the data are not conclusive.

Nerve-sparing status is another controversial risk factor for urinary incontinence. Eastham et al. identified nerve-sparing status as a risk factor at a period within which nerve sparing was relatively newly established [18]. Other large contemporary series have subsequently reproduced these findings [7, 50]. The reports that have contradicted these findings have either been small in size or with a disproportionately small number of non-nerve-sparing patients. Other series of radical prostatectomy techniques have also found nerve sparing to be a significant risk factor [33, 36, 61].

Our own radical prostatectomy series evaluating both laparoscopic and robotic radical prostatectomies found bilateral nerve-sparing status to significantly influence 1-year continence rates [9]. In a contemporary radical perineal prostatectomy series, nerve sparing proved to be a predictor of earlier recovery of continence [63]. Currently, the evidence suggests that nerve-sparing status may at least improve early continence rates and may ultimately improve total continence rates.

Previous transurethral prostate surgery has been examined in numerous series. While it always appears to be mentioned in any discussion of risk factors for urinary incontinence, the evidence does not really support this. The majority of series demonstrate that previous prostate surgery does not significantly influence continence outcomes [18, 50, 61]. Colombo et al. [12] reported a series of 109 radical retropubic prostatectomy patients who underwent previous transurethral (71 patients) or open prostatectomy (38) for benign disease. The continence rates at 6 and 12 months were 74 and 86%, respectively. There did not appear to be a statistically significant difference to their retrospectively matched controls [12]. Previous transurethral prostate surgery does not appear to be a risk factor for urinary incontinence following radical prostatectomy.

Several preoperative prostatic and urethral measurements have been identified as potential risk factors for urinary incontinence following prostatic surgery. Coakley et al. found that patients with longer preoperative membranous urethral lengths, measured by MRI, were shown by multivariate analysis to have a significantly shorter time to stable post operative continence [11]. Another multivariate analysis, by Oefelein, found that longer prostatic urethral length, measured by transrectal ultrasound, was significantly associated with a prolonged time to urinary continence [45]. Finally, Lee et al. demonstrated that patients with a prostatic apex that did not anteriorly or posteriorly overlap the membranous urethra, as shown by preoperative MRI, had a significantly earlier return of urinary continence [35]. While each of the preoperative parameters evaluated were different, they all relate to an improved intraoperative ability to maintain membranous urethral length which may ultimately be shown to shorten time to continence.

The presence of a urethrovesical anastamotic stricture appears to be a significant risk factor for urinary incontinence [18, 50]. This may ultimately be due to the fibrosis incorporating the external sphincter or related to the treatment of the stricture.

Other intriguing possible risk factors for incontinence that need more evaluation include obesity and preoperative IIEF-5 score. Ahlering et al. [2], in a robotic radical prostatectomy series of 100 patients, found that patients with a body mass index (BMI) <30 had a significantly improved continence rate compared with those with a BMI of 30 or greater. Wille et al. [61] performed a multivariate analysis of 403 men after radical prostatectomy and found a significant association between higher preoperative IIEF-5 scores and urinary continence. These are two relatively new risk factors that will require further study.

12.5 Evaluation for Urinary Incontinence Following Radical Prostatectomy

Evaluation of post-radical-prostatectomy urinary incontinence is based on the etiology of the incontinence as well as the treatment options available. Our standard evalu-

ation includes a thorough history to elicit the volume of incontinence, type of incontinence, storage symptoms, and voiding symptoms. The history will commonly paint a clinical picture of classic stress urinary incontinence, urge incontinence that may be related to overflow incontinence or detrusor overactivity, or a mixture of stress and urge incontinence.

Objective evaluation, in addition to physical examination, includes flexible cystourethroscopy and multichannel urodynamic evaluation. Cystourethroscopy is critical to evaluate the urethrovesical anastamosis for stricture. In addition, other less common findings of an obstructing bladder neck stone, urethral stricture, or bladder mass may be identified as the etiology of the incontinence.

A multichannel urodynamic evaluation including the minimum of a complex cystometrogram, pressure-flow study, and electromyelogram is also performed. The main purpose of this evaluation is to evaluate for detrusor hypoactivity or detrusor overactivity. With the bulbourethral sling as a major part of the armamentarium for incontinence treatment, it is important to demonstrate normal detrusor function prior to placement or risk permanent urinary retention. If the urodynamic evaluation demonstrates evidence of detrusor overactivity, this may direct treatment toward a trial of anticholinergic therapy before considering surgical intervention.

12.6 Management of Urinary Incontinence Following Radical Prostatectomy

There is a range of therapies available for the patient with post-radical-prostatectomy urinary incontinence. Ultimately, treatment options depend on the results of their incontinence evaluations.

12.6.1 Detrusor Overactivity

If a component of detrusor overactivity is identified by either subjective or objective assessment, it is most reasonable to offer a trial of anticholinergic therapy prior to possible surgical intervention [22, 34]. If isolated detrusor overactivity is identified with no evidence of stress urinary incontinence, and that patient fails medical therapy, one may consider second-line therapies for overactive bladder such as sacral neural modulation or intravesical botulinum toxin injection.

12.6.2 Urethrovesical Anastamotic Strictures

If a urethrovesical anastamotic stricture is identified, transurethral incision of the stricture is indicated. We generally perform this with either a holmium laser or cold knife. The patient then undergoes repeat cystoscopy in 6 months to ensure that the stricture is resolved and stable prior any incontinence intervention. Often, treatment of these strictures leads to subsequent stress incontinence or unveils stress incontinence that was not assessable with the stricture present. Managing this incontinence with surgical intervention can be very troublesome because of the possibility of recurrent stricture which would then be difficult to treat.

Management of urinary incontinence associated with problematic recurrent urethral stricture has been attempted by a range of interventions. The simplest measure would be clean intermittent catheterization or a self dilation regimen. We have found that hydrophilic catheters do well for this particular problem. Multiple groups have described the method of Urolume™ stent (American Medical Systems) placement followed by placement of an artificial urinary sphincter 6 weeks to 3 months later [3, 19]. This is performed in patients with a completely obliterated urethral lumen who fail at least one recanalization and self-calibration course. This technique has achieved excellent results with intermediate follow-up. Complex abdominoperineal, transpubic, and perineal approaches to these troublesome strictures have also been described with good success and sometimes required a subsequent artificial urinary sphincter [52, 59]. Ultimately, a supravesical continent or incontinent urinary diversion may be required if other means fail.

12.6.3 Post-prostatectomy Stress Urinary Incontinence

Once urinary incontinence due to sphincteric dysfunction has been identified by subjective or objective assessment, a range of treatment options are available. Stress urinary incontinence identified within the first year after radical prostatectomy is generally treated with noninvasive behavior therapy techniques.

We have already mentioned that there can be significant improvement seen in the first to the second year postoperatively. If one sees slow but gradual improvement, it would not be unreasonable to continue observing the patient up to 2 years. If there is a significant degree of incontinence or patient dissatisfaction at 1 year despite completing a course of behavioral therapy, we would proceed with evaluation for incontinence and surgical intervention.

12.6.3.1 Behavioral Therapy

Behavioral therapy for urinary incontinence includes pelvic floor exercises (PFE) with or without biofeedback (BFD), and with or without electrical stimulation (ES). Pelvic floor exercises generally include multiple sessions of formal instruction by a physical therapist. Biofeedback is performed by using either an anal pressure probe or patch electrode to transmit a visual display to the patient that the appropriate muscular contraction is being performed. In theory, this visual reinforcement is thought to improve the patient's quality of exercise. Electrical stimulation utilizes an electric current sent to the pelvis to stimulate contraction of the pelvic floor musculature. In theory, this is helpful in patients who are initially unable to volitionally contract the appropriate pelvic floor muscles or to improve awareness of the muscles they should be working.

There have been numerous reports on the role of behavioral therapy in postprostatectomy stress urinary incontinence. Multiple studies have shown an improvement in time to continence with the use of PFEs but not an overall change in long-term continence outcome [23, 46]. The adjunctive use of biofeedback or electrical stimulation does not appear to add any benefit over PFEs alone [5, 62].

12.6.3.2 Medical Therapy

At this time, there is no pharmacological treatment approved for stress urinary incontinence in men; however, duloxetine has been approved for use in women for the treatment of moderate and severe stress urinary incontinence by the European Medicines Agency since August 2004. Duloxetine is a balanced and potent inhibitor of serotonin and norepinephrine reuptake. The exact mechanism by which it functions has not been clearly elucidated, but it has been found to increase bladder capacity and increase periurethral striated muscle electromyographic activity in cats through a central neural mechanism [55].

Three phase-3 double-blind, placebo-controlled studies involving 1635 women in North America, South America, Europe, Australia, and Africa all showed significant improvement in stress urinary incontinence versus placebo [17, 43, 57]. While efficacy was clearly demonstrated in these studies, there were two other notable findings, a high discontinuation rate and a high placebo response. The common side effects were nausea, fatigue, insomnia, dry mouth, and constipation. The discontinuation rate due to side effects ranged from 17% to 24%. With regard to placebo response, 33–43% of patients who received placebo had 50–100% decreases in incontinence episode frequency.

There were some early studies looking specifically at the off-label use of duloxetine for the treatment of post-prostatectomy urinary incontinence. Filacamo et al. evaluated 112 patients undergoing radical prostatectomy and randomized patients to pelvic floor muscle training with or without duloxetine 40 mg twice daily for 16 weeks, 10 days after catheter removal [24]. There appeared to be some benefit from duloxetine up to 16 weeks, but the results reversed at the twentieth week. Shortly after discontinuing the medication, continence rates were actually worse in the duloxetine treatment group at 20 and 24 weeks. These data suggest that the role of medical therapy may be better in a treatment setting rather than a rehabilitative setting. Other studies performed have been too small to make any definitive conclusions.

The central-acting role of duloxetine, the relatively high discontinuation rate due to side effects, and the high placebo responses in the three phase-3 studies will likely play an important role in determining the efficacy of duloxetine in men with post-prostatectomy urinary incontinence. The proposed central-acting mechanism of duloxetine requires intact innervation of the external sphincter. The integrity of this neural pathway after radical prostatectomy is uncertain. Secondly, high discontinuation rates due to side effects will make a potential prophylactic role after surgery difficult. Finally, most radical prostatectomy patients recover their urinary control within 1 year. The presence of a large placebo response in previous studies necessitates large randomized, double-blind, placebo-controlled trials in men to accurately evaluate the efficacy of medical therapy.

12.6.3.3 Transurethral Injection Therapy

Transurethral injection therapy for post-prostatectomy urinary incontinence has been described using polytetrafluoroethylene, zirconium carbon-coated beads (Durasphere), and glutaraldehyde cross-linked collagen. Animal studies demonstrating

granuloma and emboli formation led to the discontinuation of polytetrafluoroethylene injections in the United States [39]. While Durasphere and collagen are equally available, most of the long-term published reports utilize only collagen.

Skin testing is required 1 month prior to collagen injection. Then using either local or general anesthetic, collagen is injected submucosally under direct vision at the urethra proximal to the external sphincter at the right and left sides or using a four-quadrant technique (at the 2, 4, 8, and 10 o'clock positions) [1, 15]. Side effects are usually minor but include self-limiting hematuria, transient urinary retention, and urinary tract infection [20].

Urinary continence outcomes using transurethral collagen have been disappointing in terms of overall continence rate as well as durability of response as shown in Table 12.2. Short-term reports have demonstrated cure/marked improvement rates as high as 66 or 75% social continence [1, 15]; however, reports with longer follow-up have demonstrated a 2% cure rate at 1 year and 15–44% cured/greatly improved rate overall [20, 53, 60]. Despite its overall poor outcomes, transurethral collagen does have a role in the select patient; these include patients with significant comorbidities that would not tolerate general anesthesia and patients with detrusor hypoactivity and mild incontinence.

12.6.3.4 Male Slings

The concept of upward compression of the bulbous urethra for the treatment of post-prostatectomy urinary incontinence was initially introduced in 1972 by Kaufman [30]. Since that time, two bulbourethral sling techniques have recently evolved, one using retropubic needle passage and one using bone anchors. Male slings now play an important role as an intermediate alternative to the artificial urinary sphincter. One important caveat is that there must be no evidence of detrusor areflexia. In such cases, an artificial sphincter should be considered, or one could proceed with a sling as long as the patient has the expectation for the high possibility of permanently requiring clean intermittent catheterization.

The technique of the bone-anchored sling, also known as the InVance™ male sling (American Medical Systems), was originally described by Comiter [13]. Briefly, it involves an approximately 4-cm incision in the perineum. The urethra is minimally dis-

Table 12.2 Outcomes for collagen injection for post-prostatectomy urinary incontinence. *NR* not reported

Reference	No. of patients	Mean follow-up (months)	Median follow-up (months)	Cure/ improved (%)	Mean duration of response (months)
[1]	72	10	NR	66	NR
[20]	47	38	NR	15	NR
[53]	62	NR	29	39	17.5
[60]	322	40	NR	44	7.3

sected down to expose fat around the bulbospongiosus or to expose the bulbospongiosus muscle itself. A 2-cm dissection of the medial aspects of the descending pubic rami is performed and titanium bone screws loaded with a pair polypropylene sutures are inserted on the pubic rami symmetrically using either a four- or six-suture technique. The sutures are then used to tie down either a synthetic, absorbable, or composite piece of mesh that compresses the bulbar urethra to a pressure of 150 cm of H_2O.

The technique of bulbourethral sling utilizing retropubic needle passage was originally described by Schaeffer et al. [51]. Briefly, it involves placement of a suprapubic catheter and two separate incisions. Three tetrafluoroethylene bolsters are placed beneath the bulbar urethra through a perineal incision. Nonabsorbable sutures attached to each end of the bolsters are then passed from the perineal incision to a suprapubic incision using a modified Stamey needle. The sutures are then tensioned to 150 cm of H_2O and tied over the rectus fascia. Retightening involves reopening the suprapubic incision and retying the nonabsorbable sutures. Similar slings using a strip of polypropylene or a composite of polypropylene and porcine skin collagen as the sling material instead of tetrafluoroethylene have been described [28, 41].

Complications for the bone-anchored sling include transient perineal pain/scrotal numbness (12–16%), transient urinary retention (4–12%), infection/urethral erosion (2–8%) requiring removal, screw dislodgement requiring reoperation (4%), and perineal hematoma (rare) [8, 13, 14, 21, 49]. Complications for the bulbourethral sling using retropubic needle passage include prolonged perineal pain (12–100%), urethral erosion/infection requiring removal (8–11%), urinary retention requiring tension release (6%), transient retention (2%), and unrecognized suture in bladder (2%) [28, 41, 51, 54].

In terms of outcome, Table 12.3 shows short-term and intermediate-term results for the various slings. With the bone-anchored slings, Comiter's series has the longest follow-up and demonstrates the best results [14]. The series by Castle et al. [8] was not as positive, but this could be explained by their variation in technique of preserving the fat around the bulbospongiosus muscle. Dikranian et al. [16] demonstrated an improved performance with synthetic/nonabsorbable mesh over absorbable mesh with the bone-anchored sling. Looking at all the bone-anchored series, urinary outcomes appear comparable to the artificial urinary sphincter. While the Castle et al. series [8] appears to be more of an outlier, further study will ultimately answer this question.

The outcomes of the slings utilizing retropubic needle passage appear comparable to the bone-anchored series with intermediate follow-up (Table 12.3); however, in addition to requiring an additional incision, the retropubic needle passage group has a much higher complication rate. Additionally, the results shown in Table 12.3 reflect a result achieved with 23% requiring retightening and 5% requiring multiple retightenings. When weighing all the factors, it appears that the bone-anchored group has at least comparable continence outcomes, with a simpler procedure and lower complication and reoperation rates. Ultimately, the decision on the type of sling should be made at the discretion of the treating urologist.

12.6.3.5 Artificial Urinary Sphincter

The artificial urinary sphincter (AUS) has long been the gold standard for the treatment of post-prostatectomy urinary incontinence. Research has moved towards find-

Table 12.3 Outcomes for male slings for post-prostatectomy urinary incontinence. *NR* not reported, *NA* not applicable

Reference	Type	Depth of dissection	Sling material	No. of patients	Mean follow-up (months)	Median follow-up (months)	Cured (%)	Improved (%)	Social continence (%)
[16]	Perineal bone anchored	Bulbospongiosus exposed	Porcine	20	18	NR	56	31	NR
	Perineal bone anchored	Bulbospongiosus exposed	Synthetic	16	18	NR	87	13	NR
[28]	Retropubic needle passage	NA	Porcine/ synthetic composite	19	NR	14	69	6	NR
[8]	Perineal bone anchored	Subcutaneous fat preserved	Synthetic	42	18	NR	16	24	40
[49]	Perineal bone anchored	Subcutaneous fat preserved	Synthetic (17% absorbable)	45	24	NR	37	37	NR
[13]	Perineal bone anchored	Bulbospongiosus exposed	Synthetic	48	NR	48	65	15	NR
[21]	Perineal bone anchored	Bulbospongiosus exposed	Synthetic	50	NR	6	50	26	NR
[54]	Retropubic needle passage	NA	Synthetic	71	48	NR	81		NR
[42]	Retropubic needle passage	NA	Synthetic	49	32	NR	NR	NR	63

Table 12.4 Outcomes for artificial urinary sphincter for post-prostatectomy urinary incontinence. *NR* not reported

Reference	No. of patients	Mean follow-up (months)	Median follow-up (months)	Cured (%)	Improved (%)	Social conti-nence (%)	Patient satisfaction (%)
[37]	65	28	NR	20	72	NR	90
[32]	27	35	NR	NR	NR	81	N
[58]	98	44	47	19	70	NR	89–92

ing alternative, less invasive methods at treating incontinence, but the artificial urinary sphincter continues to be one of the mainstays of urinary incontinence treatment.

Table 12.4 summarizes urinary outcomes with the artificial urinary sphincter. The number of cured patients (19–20%) appears to be somewhat low for a treatment considered the gold standard; however, improvement rates (70–72%) seem to bring patient satisfaction rates to an impressive 90%.

The well-known complications with the AUS include infection/urethral erosion (3–12%) and mechanical malfunction (1–9%). Additionally, the reoperation rate for the AUS ranges from 18 to 36% [10, 32, 37, 58]. There appears to be a 50% 5-year revision-free rate [10]. Even with the high need for revision, Litwiller et al. still found a 90% patient satisfaction rate in patients undergoing revision [37].

The introduction of the male sling in the past 7 years has brought forward a nice intermediate option for those patients suffering from mild urinary incontinence, or those with moderate to severe urinary incontinence that are hesitant to undergo an artificial urinary sphincter. The higher degree of complexity associated with the AUS combined with its high reoperation rate make it a much less attractive option than a male sling; however, the AUS will continue to have its role in the post-prostatectomy patient with severe urinary incontinence, those with incontinence refractory to a sling, and those with detrusor areflexia or hypoactivity.

12.7 Conclusion

Urinary outcomes following robotic-assisted laparoscopic radical prostatectomy are remarkably good. It will be exciting to track the course of overall continence rates and time to continence parameters to accurately measure the benefit of robotic technology in the execution of the anatomic radical prostatectomy. Related to this are preoperative risk factors for urinary incontinence that may ultimately be equalized with improved surgical technique. It also appears that incontinence intervention has made great progress. Behavioral therapies accelerate the recovery of urinary continence. The development of the bone anchored and retropubically passed bulbourethral slings provide an intermediate option for surgical intervention, not readily available a few years ago. We suspect that as prostatic surgical techniques improve, the need for incontinence intervention will dramatically diminish.

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Chapter

13 Erectile Function After Robotic Prostatectomy: Anatomical Aspects and Treatment

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13.1 Introduction

Prostate cancer has a significant impact on men's quality of life in the United States. More than 230,000 new cases diagnosed each year and more than 30,000 annual deaths attributed to this malignancy [1]. The maintenance of satisfactory quality of life is the principle concern for more than 45% of men who elect treatment for localized prostate cancer [2].

A number of options are available for treating localized cancer of the prostate disease/free survival rates nearly equivalent for contemporary therapies. Major efforts are aimed at reducing the morbidity related to curative treatment. Radical prostatectomy (RP) has been considered the gold standard treatment for organ-confined prostate cancer for several decades [3]. Urinary incontinence and erectile dysfunction (ED) are the two most important quality-of-life issues reported following RP. Improvement of surgical techniques has significantly reduced postoperative incontinence rates; however, most urologists still report as significant long-term postoperative complications related to RP [3, 4].

In the past, ED following RP was not an overwhelming concern, as most prostate cancers were detected in older men [5]. With the advent of prostate-specific antigen (PSA) screening, which began in the late 1980s, prostate cancer is now detected at early stages in young men. Based on this, research has begun to focus on the pathophysiology and prophylaxis of ED following RP [6].

13.2 Incidence

Published reports on ED following RP range from 40 to 85% at leading centers [4, 7]. While an individual surgeon's experience [8] and technique remain the dominant variables in the outcome, several other factors also could affect postoperative ED, including the patient's age [7, 9–11], preoperative sexual function [11, 12], and concomitant medical diseases.

The CaPSURE study [13] showed that only 20% of patients returned to their preoperative baseline potency levels 1 year after radical prostatectomy. Similarly, the Prostate Cancer Outcomes Study [14] revealed changes in urinary and sexual function in 1291 men who had undergone radical prostatectomy for clinically localized prostate cancer. At 18 months or more following radical prostatectomy, 59.9% of men self-reported having ED.

A more recent report from the era of nerve-sparing prostatectomy demonstrates that concerns about sexual function remain strong. In a study of 129 patients with localized prostate cancer, the subjects were given a trade-off between potential survival advantages and potential adverse outcomes. A concern about ED was high. Patients were willing to trade an average of 1.8 months of life expectancy. When the patients willing to trade life for sexual function were age stratified, patients younger than 70 years of age were willing to trade off a greater amount of life to preserve sexual function than those beyond 70 years of age [15].

The Scandinavian Prostatic Cancer Group [16] reported a 45% incidence of ED for patients selecting the watchful-waiting option as compared with 80% for those opting for radical prostatectomy.

Walsh and Donker first introduced nerve-sparing surgery in 1982 [17]. They reported potency rates of 86% in patients after bilateral nerve sparing RP [4].

Contemporary open surgical techniques results in an estimated 60–85% recovery of erectile function in men with normal preoperative potency [18–21] and serve as the measure by which the new closed techniques of radical prostatectomy (laparoscopic or robotic) must be compared. Rozet et al. [22] reported their experience with extraperitoneal laparoscopic radical prostatectomy (LRP). This group performed more than 600 LRPs and evaluated their outcomes prospectively. The investigators used International Index of Erectile Function (IIEF-5) to evaluate baseline and postoperative (6 months) erectile function in 231 patients. From a total of 89 previous potent men (IIEF >20), the postoperative potency rate was 43% at 6 months in those with bilateral nerve bundle preservation and who used tadalafil 10 mg every other day [22].

Recently, robotic radical prostatectomy (RRP) has been introduced with much enthusiasm. This technique offers several advantages that could improve the outcomes based on 3D visualization, tissue magnification, and a very precise dissection. Several authors have reported excellent results after RRP [23, 24] that we discuss later (Table 13.1).

13.3 Pathophysiology

Radical prostatectomy causes ED by affecting the neurovascular mechanisms that initiate the erectile response. After bilateral nerve-sparing radical prostatectomy, erectile function is impaired in the early postoperative period because of an apparent "neuropraxia," that is, a relative trauma invoked on the neurovascular bundles during surgical dissection. The mechanism of cavernous nerve-fiber injury involves, in part, Wallerian degeneration with a loss of normal nerve tissue connections to the corpora cavernosal and associated neuroregulatory functions. Both of these processes cause cavernosal tissue degeneration and atrophy [25, 26].

Several authors have implicated vascular compromise as one of the important causes of ED following RP. It is well known that damage to the neurovascular bundle can cause cavernosal arterial insufficiency. Breza et al. [27] reported that accessory

Table 13.1 Potency recovery after nerve-sparing robot-assisted laparoscopic prostatectomy: other series. *VIP* vasoactive intestinal polypeptide

Reference	No. of cases	Technique	Potency definition	Data collection	Potency rates (%)		
					3 months	6 months	12 months
[24]	36	Bipolar	Intercourse	IIEF-5	36	–	–
	51	CFT			68	–	–
[44, 45]	300	IFNP	Return to baseline	UCLA-PCI	33[a]	52[a]	61[a]
					53[b]	61[b]	80[b]
[46]	325	EX technique	IIEF >21	IIEF-5	46	–	–
[23]	154	VIP	Intercourse	SHIM	–	–	96
		Veil of Aphrodite					

VIP: Vattikuti Institute Prostatectomy; CFT: Cautery-Free Technique; EX: Extraperitoneal;
IIEF: International Index of Erectile Function; IFNP: Interfascial Nerve Preservation
UCLA-PCI: University of California – Los Angeles Prostate Cancer Index
[a] After unilateral Nerve-Sparing [b] After bilateral Nerve-Sparing

pudendal arteries are often the major blood supply in selected cases. This group hypothesized that damage to these arteries might be the main cause of ED; however, this opinion was not universally accepted. In 1995, Polascik and Walsh reported that accessory pudendal arteries were identified in only 4% of cases [28]. Recently, this group published that preservation of the accessory pudendal artery was associated with a significant increase in potency rates. They also reported that the time needed for recovery of spontaneous erection was significantly less in the vascular preservation group. They concluded that preservation of the accessory pudendal artery at the time of surgery (if identified) may favorably influence sexual function [29].

The fibrosis (collagen accumulation) has been reported as the most probable cause of ED in patients with arterial insufficiency. The exact mechanism of collagen accumulation in patients with penile hypoxia has not been established. This opened a new era of interest in the field of pharmacological prevention [10, 11].

In conclusion, ED after RP has a multifactorial etiolgy. Psychological and neurovascular causes are among the most important factors. Penile hypoxia results from neuropraxia and altered vascular factors. Penile hypoxia is the most important precipitating factor in formation of cavernosal fibrosis with subsequent venous leak and has been implicated as the most important cause of long-term ED after RP [6].

13.4 Anatomical Foundations About Nerve-sparing Surgery

13.4.1 Tri-zonal Concept for the Nerve-sparing Robotic Prostatectomy

In the classical concept, the neuroanatomy for nerve-sparing pelvic surgery has been described in the limited area, i.e., only posterolateral aspect of the prostate and the seminal vesicle [30]. Many urologists have imagined the preserved neural component to be a bundle-like structure. Recent studies, however, report the origin of the cavern-

ous nerve is a distal branch of the pelvic splanchnic nerve (PSN). Also, these nerve fibers join the hypogastric nerve (HGN) with a spray-like arrangement along the lateral wall of the rectum [31]. We should understand the pelvic neuroanatomy to be located in a wider area in order to perform nerve-sparing surgery. Since we approach the prostate in an antegrade fashion during robotic prostatectomy, we need to understand the anatomy around the proximal and posterior aspect of the prostate. From a practical standpoint, the relevant neural tissue that we encounter during robotic prostatectomy can be grouped into three broad zones (Fig. 13.1), the proximal neurovascular plate (PNP), the predominant neurovascular bundles (PNB), and the accessory distal neural pathways (ANP) [32].

13.4.1.1 Proximal Neurovascular Plate

The PNP is an integrating center for the processing and relay of neural signals. This plate is located lateral to the bladder neck, seminal vesicles, and branches of the inferior vesical vessels. It is thick in the center near the seminal vesicles. Specifically, depending on variations in anatomy and prostate size, the PNP is located 5–10 mm (average 5 mm) lateral to the seminal vesicles, 2–7 mm (average 3 mm) thick, 5–25 mm (average 7 mm) wide, and 4–30 mm (average 9 mm) in length. It is located within 4–15 mm (average 6 mm) of the bladder neck, within 2–7 mm (average 5 mm) of the endopelvic fascia, and overlaps 0–7 mm (average 5 mm) of the proximal prostate.

The PNP extends posterolateraly to the base of the prostate and cavernous nerve candidate's course in the most distal part. Distally the plate continues as the classical

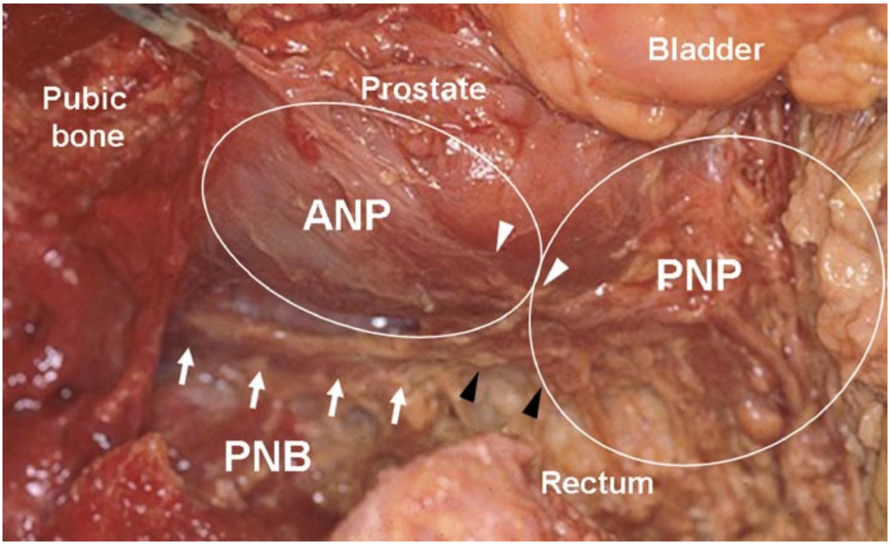

Fig. 13.1 The tri-zonal concept of proximal neurovascular plate (*PNP*), predominant neurovascular bundles (*PNB, arrows*), and accessory distal neural pathways (*ANP*) in a fresh cadaver. *White arrowheads* indicate the continuity of PNP and ANP, and *black arrowheads* are PNP and PNB

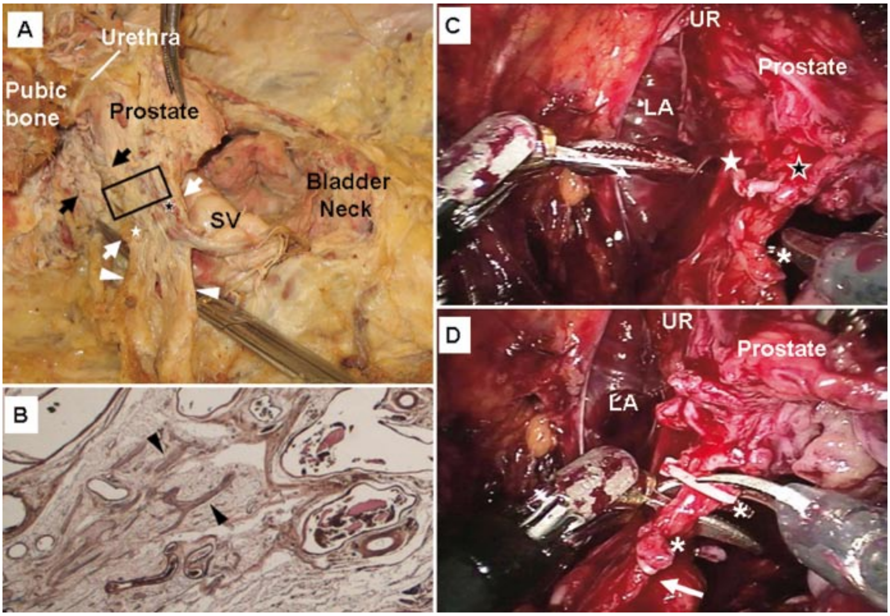

Fig. 13.2 Panel A is cadaveric dissection showing the relationship between seminal vesicle (SV) and proximal neurovascular plate (PNP, white arrowhead, white arrow and white star) according to the procedure of robotic prostatectomy. Bladder neck transaction is performed, and the prostate is lifted up by the forceps. PNP is intermingled with vascular pedicle (black star) of the prostate. Also you can see the PNB (Predominant neurovascular bundle) represented by black arrows and black box.Panel B is histologic study stained by hematoxylin and eosin in small square in Panel A. Black arrowhead, ganglion cell cluster; Panel C and D are the robotic procedure. Viewing these structure laterally. (Panel C), we should estimate where is the approximate border between PNP and vessel component, although they are actually intermingled. We have already cut a part of the vessels using a clip (asterisk). Black star, PNB; White star, intermingled structure of vascular and neural component. Panel D shows we thread the left hand instrument through the border, ligate the residual vessels using clip, and are cutting sharply. UR, urethra; LA, levator ani. See the vascular pedicle between asterisks. White arrow represents the proximal end of vascular pedicle

neurovascular bundle while a few branches travel through the fascial and capsular tissue of the prostate as accessory pathways. During robotic prostatectomy, the PNP intermingles with the vessel pedicle of the prostate. It is impossible to separate them clearly (Fig. 13.2).

13.4.1.2 Predominant Neurovascular Bundles

This corresponds to the classical bundle; however, it carries the neural impulses not only to the cavernous tissue, but also to the urethral sphincter and to the end of the levator ani muscle, i.e., puboperinealis muscle (Fig. 13.3) [33]. The predominant neurovascular bundles (PNB) is enclosed within the layers of levator fascia and/or lateral

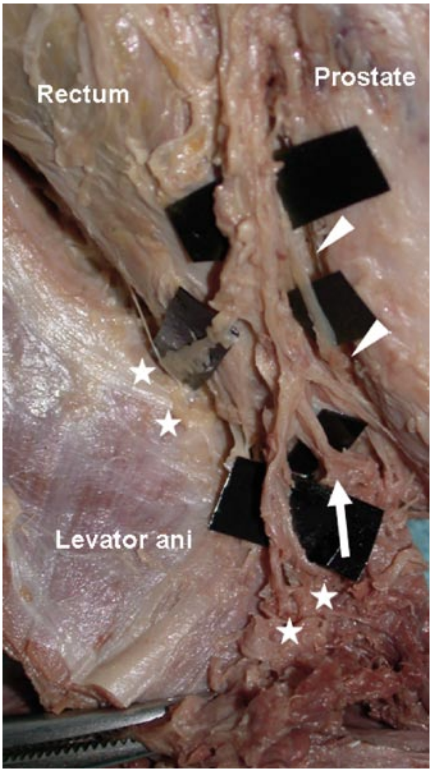

Fig. 13.3 The distal part of right PNB. The PNB contains many nerve fibers to the cavernous tissue (*arrow*), urethral sphincter (*arrowheads*), and the bottom of the levator ani muscle (*stars*)

pelvic fascia and is located at the posterolateral aspect of the prostate. The course varies from base to the prostatic apex. We could not distinguish the PNB from the accessory distal neural pathways histologically, that is, no clear sheath encircles the PNB.

The PNB occupies the groove between the prostate and the rectum. It is thickest at the base and has the most variable course and architecture near the apex. Our anatomical studies showed the cavernous nerve candidate continued to the PNB through the distal part of the PNP. The fibers from the HGN are more ventral and those from the PSN are more dorsal at the base of the prostate [31].

13.4.1.3 Accessory Distal Neural Pathways

There have been discussions about putative accessories besides the PNB around the prostate. They were usually described within the layers of the levator fascia and/or lateral pelvic fascia, on the anterolateral and posterior aspect of the prostate, which may serve as additional conduits for neural impulses. Many cadavers (75%) had the proximal third of the prostate covered by the PNP where these nerve fibers were most prominent.

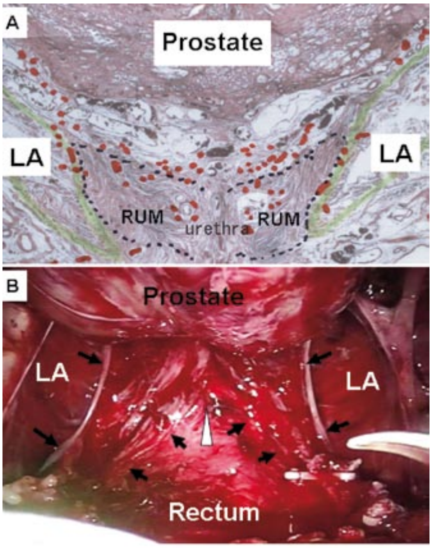

Fig. 13.4. Apical transaction. **A** Frontal section through the membranous urethra. Many nerve fibers (*red dots*) exist behind the apex of the prostate between bilateral levator ani (*LA*). Some of them penetrate the rectourethral muscle (*RUM*) encircled by *dots*. Hematoxylin and eosin staining. **B** The surgical procedure. We can see the many nerve fibers behind the apex of the prostate during robotic prostatectomy. Bilateral PNB (*arrows*) overlapped behind the apex and formed posterior plexus (*arrowhead*)

Additional pathways were noted posteriorly. In 25% of specimens, a posterior pathway arose from medial aspect of the PNP near the base of the seminal vesicles. Other accessory branches occasionally formed an apical plexus on the posterolateral aspect of the prostatic apex and urethra incorporating fibers from both the PNB. This distal plexus was observed in 35% of cases, penetrating the rectourethral muscle (Fig. 13.4). This could potentially act as a neural pathway for not only cavernous tissue but also the urethral sphincter. It could also serve as a safety mechanism for providing backup neural crosstalk between two sides. In 10% of cases the fibers were circumferential at the apex.

13.4.2 The Distribution and Functional Classification of the Autonomic Ganglion Cells

13.4.2.1 Distribution

In nerve-sparing prostatectomy, the major components intended for preservation include nerve bundles; however, ganglion cells (GC) have received little consideration in this strategy. Surgical damage to GCs can result in a much worse outcome than injury to nerve fibers, since GCs cannot repair themselves [34]. To our knowledge, we were the first to report the distribution of the autonomic GCs in the male pelvis [35].

Of course, autonomic CG existed in the macroanatomical nerve components. There were many ganglion cells in and along the PSN, especially distally near the PNP. The HGN, previously believed to contain many sympathetic postganglionic nerve fibers, also contained GCs along its distal course near the distal ureter. The GCs in PNP were not attached to the seminal vesicle but were separate from it by just 1.0 mm. Great

intersubject differences in cell number were evident in all three-nerve components. Although PNB contained more peripheral nerve fibers than the above-mentioned nerve components, GCs were evenly distributed along the prostate from base to apex.

Autonomic CG also existed along viscerally, not in the macroanatomic nerve components. At 1-mm interval sections, we examined the distribution of ganglion cells in detail, according to the robotic procedure. We detected many ganglion cells in the PNP (250–1113 cells) and in the PNB (66–908 cells). After the bladder neck transaction, we recognized the intermingled structure of the PNP and the vascular component. Ganglion cells were distributed widely throughout the PNB, especially laterally or posteriorly (Fig. 13.5). In particular, these ganglion cells were attached to the prostatic capsule or even embedded within the capsule. In the accessory distal neural pathways, some ganglion cells existed in the bladder/prostate junction, dorsal aspect of seminal vesicle, dorsal aspect, and near apex of the prostate. Almost all nerve fibers and GCs converged to the apex. There were almost no ganglion cells in the ventral aspect of the prostate and levator ani muscle.

As shown in the macroanatomic nerve components, intersubject differences were evident in all sites. Significant variations are noted in the dorsal aspect and near the apex of the prostate. This might lead to varying postoperative outcomes with respect to patient quality of life (QOL).

The control of the pedicle, the release of the PNB, and the apical transaction are extremely important steps in the preservation of the GCs. This is because several CGs exist along the plane of dissection.

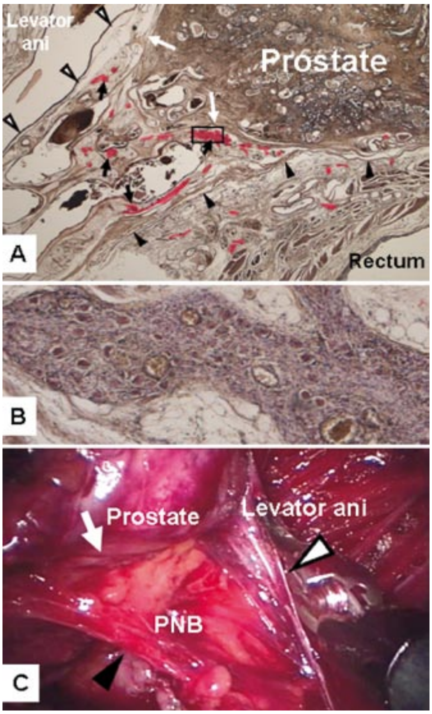

Fig. 13.5. Release of predominant neurovascular bundles (PNB). **A** Horizontal section of the posterolateral prostate. Ganglion cells (*black arrows*) in PNB are along or attaching to the posterolateral aspect of the prostate capsule (*white arrows*). Ganglion cells exist in the triangle of the prostate capsule, lateral pelvic fascia (*white arrowheads*), and Denonvillier's fascia (*black arrowheads*). Red, neural component. **B** Magnification of *small square* in **A**. Hematoxylin and eosin stain. **C** The robotic procedure. We should imagine PNB as a triangle, which is seen in **A**

13.4.2.2 The Functional Classification

The functional classification of autonomic nerves was actually not very simple. Butler-Manuel et al. [36] reported the uterosacral ligament containing the HGN showed positive immunostaining of both tyrosine hydroxylase (TH) as a sympathetic nerve marker and vasoactive intestinal polypeptide (VIP) as a parasympathetic nerve marker. We demonstrated that TH-positive and peptide histidine isoleucine (PHI, as a parasympathetic marker)-positive GCs were intermingled in one ganglion attaching to the posterolateral surface of the prostate. TH-positive cells were also seen in all GC clusters in the male pelvis, e.g., the mean TH-positive cell ratio in a GC cluster was 62% in HGN and 36% in PSN [35]. Simple classification of macroanatomic pelvic autonomic nerve components as sympathetic or parasympathetic would seem misleading.

13.5 Robotic Surgical Techniques (Modifications) to Preserve Sexual Function

13.5.1 Athermal Robotic Technique (Cornell University)

13.5.1.1 Bladder Neck Transection

Bladder neck transection is performed with a 30° lens angled downwards (Fig. 13.6). We place a stitch on the anterior surface of the prostate to prevent backbleeding and also for traction. Another bunching stitch is placed in the bladder superficially for traction. Using our technique of the bimanual pinch [37] blunt robotic instruments, the prostate is trapped on both sides and pulled proximally to identify the prostatovesical junction. The surface is scored to precisely mark the prostatovesical junction anteriorly. The dissection is deepened until the Foley catheter is seen.

Identification of the Foley catheter ensures that the anterior bladder neck has been incised appropriately. The catheter is delivered out of the bladder. Using the shaft of the catheter as a landmark, the mucosa of the posterior bladder neck is incised precisely. The posterior incision is modified according to the size and configuration of the prostate. We then develop a plane behind the posterior wall of the bladder neck that will expose the retrotrigonal layer [38]. Cutting this layer exposes the vasa and the seminal vesicles. Electrocautery is avoided from this point onward.

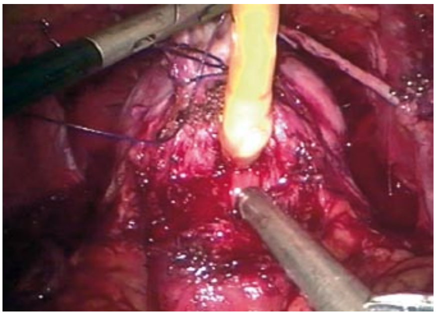

Fig. 13.6 Bladder neck transection

13.5.1.2 Seminal Vesicle and Vas Dissection

Division of the retrotrigonal fascia reveals the vas deferentia and the seminal vesicles (Fig. 13.7). This incision is further extended laterally to allow retraction of bladder neck cranially. The vasa are grasped and surrounding vessels are controlled with 5-mm surgical clips. The seminal vesicles are dissected similarly starting in the medial avascular plane and staying on the surface of the glands to avoid damage to the proximal neurovascular plate. The key to successful nerve sparing is meticulous dissection, staying close to the surface of the seminal vesicle and avoiding dissecting the outer layers, clear visualization, control of individual vessels using small clips, and avoiding electrocautery. Both seminal vesicles and vasa are lifted up and secured to the prostate with a stay suture, which helps in retraction.

13.5.1.3 Incision of Denonvillier's Fascia and Posterior Dissection to the Apex

With traction over both vasa and seminal vesicles an inverted U-shape incision is made over the base of the prostate and continued on the prostatic undersurface (Fig. 13.8). Care should be taken to leave both layers of the Denonvillier's fascia on the specimen and expose the prerectal fat. This dissection is continued distally to the apex.

13.5.1.4 Lateral Pedicle Control

Upward traction is exerted on the vas and seminal vesicles with the stay suture to make the pedicles more prominent (Fig. 13.9). Once the prostatic pedicle is easily differentiated from the bundle, then selective clipping or ligation of the prostatic vessels is performed. The pedicles are controlled close to the base. Electrocautery and mass ligature are avoided and small clips and individual pedicle controls are preferred.

13.5.1.5 Release of Neurovascular Bundles

The prostate is retracted on one side and the lateral pelvic fascia is exposed (Fig. 13.10). Entering the triangular space between Denonvillier's fascia, lateral pelvic fascia and the prostate best preserves the nerves. The surgeon has to reflect the lateral pelvic fascia off the prostate. It is incised in a plane superficial to the prostatic fascia from apex to prostatovesical junction, always staying parallel to the neurovascular bundles. This maneuver releases the bundles and provides landmarks for later antegrade dissection. Dissection is totally athermal with clips preferred for any vascular control. This dissection is continued distally to the apex and laterally over the bundles to expose the neurovascular triangle described above. Further dissection proceeds within this triangle to release the bundles staying close to the prostatic fascia. Near the apex a few perforators are clipped and transected allowing the neurovascular bundles to fall away from the apex.

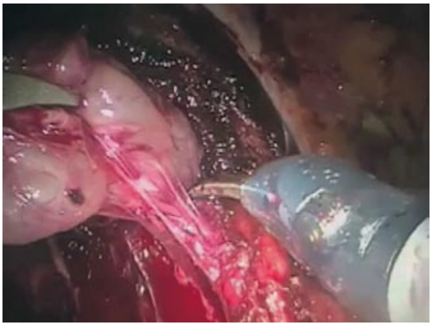

Fig. 13.7 Seminal vesicle and vas dissection

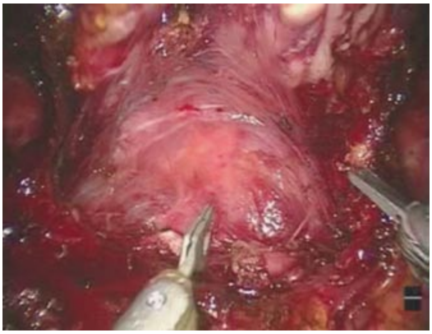

Fig. 13.8 Incision of Denonvillier's fascia and posterior dissection to the apex

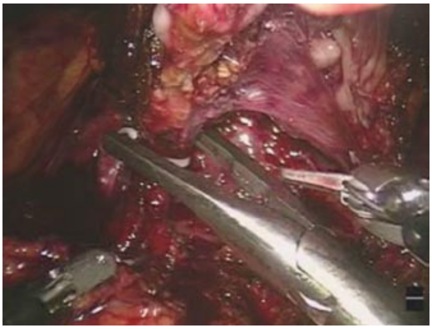

Fig. 13.9 Lateral pedicle control

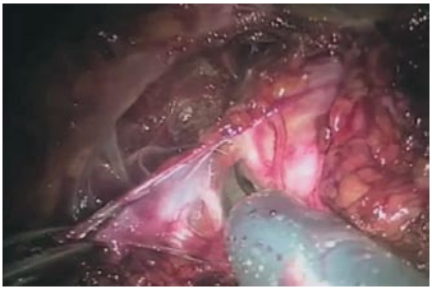

Fig. 13.10 Release of neurovascular bundles

13.5.1.6 Apical Dissection, DVP Ligation and Urethral Transection

Delicate apical dissection of the prostate with preservation of the puboprostatic ligaments is done. The apex is freed as much as is possible with blunt dissection and minimal or no use of cautery. The arcus tendinous, the lateral leaflet of the endopelvic fascia, and the puboprostatic ligaments are left in continuity, and these, along with the posterior hammock-like puboperinealis, muscle give circumferential support to the urethra. A puboprostatic ligament-sparing DVC suture is taken with 1-0 Vicryl taking cognizance of the rhabdosphincter and the neural branches for continence. The anterior urethra is cut proximal to the puboprostatic ligaments. The posterior urethra is then cut ensuring dissection and separation of the neurovascular bundles and taking cognizance of the accessory nerves posteriorly.

13.5.2 "Veil of Aphrodite" Nerve Sparing

The robotic arms are equipped with a pair of articulated scissors and bipolar forceps. The packet of tissue containing the neurovascular bundles is freed by incising the lateral pelvic fascia anterior–medially and parallel to the neurovascular bundles between the prostatic venous plexus and the prostatic capsule. The posterolateral surface of the prostate is sharply cleared by dropping a layer of fascia, fat, nerves, and blood vessels from the base and working towards the apex. Most of the dissection occurs in a relatively avascular plane, such that the neurovascular bundles can be freed from the prostate laterally, easily requiring only minimal cautery use. Once the lateral pedicles have been isolated, Hem-o-lock clips (Weck, Research Triangle Park, N.C.) are applied close to the prostate. The bundle is divided sharply on both sides thus exposing a relatively avascular plane for the rest of the dissection. Minimal bipolar cautery is used as the neurovascular bundles are bluntly freed posterolaterally from the capsule. If the endopelvic fascia has not been opened previously, it can easily be accomplished at this point to facilitate the dissection.

It is important to attempt to spare the accessory penile and cavernosal nerves which may course along the side of the prostate. Animal and human studies suggest that there may be accessory cavernosal nerves that run underneath the lateral pelvic fascia on the anterolateral surface of the prostate [41]. These nerves may be physiologically relevant in erectile function. Given the improved vision and robotic manipulation, it is feasible to dissect this lateral fascia free of the prostate. They have developed an atraumatic technique of dissection of the neurovascular bundles and lateral prostatic fascia. In young patients without significant risk for extraprostatic extension, the lateral periprostatic fascia is preserved, creating a veil of tissue named the "veil of Aphrodite" [23, 39, 40].

The authors recently refined the technique of nerve preservation in select patients with low-risk disease by extending our sparing of the previously described atraumatic veil of Aphrodite lateral prostatic fascia to the anterior surface of the prostate. A plane of tissue between the dorsal venous tributaries and the prostate anteriorly can be developed after lateral fascia has been reflected. They named the anterolateral periprostatic fascia-sparing surgery the "Super VIP."

13.5.3 "Cautery-Free" Neurovascular Bundle Preservation

After dividing the posterior bladder neck, the ampulla of each vas was isolated and dissected until the tip of the seminal vesicle was exposed. The seminal vesicles were dissected using scissors and judicious use of bipolar cautery. Denonvilliers fascia was entered in the midline and the rectum mobilized to the level of the prostatic apex. This delineated the prostatic vascular pedicles (VPs). Laparoscopic bulldog clamps (30 mm;) [24, 42, 43] were placed on the VPs at least 1 cm from the prostate. From this point, only scissors were used to divide the VPs very close to the prostate.

The lateral prostatic fascia was incised along the prostate, and the NVB was gently dissected off the prostatic capsule. After completely mobilizing the NVB down to the urethra, FloSeal (Baxter) was applied along the entire length of the NVB. The FloSeal was then covered with a dry 1- to 5-cm sheet of Gelfoam (Pfizer, New York, N.Y.). This acts as a protective cover to keep the FloSeal particles in place.

After the prostate was removed, and the surgical field was clear, the bulldog clamps were removed sequentially. The VPs were observed for pulsatile bleeding and, if present, the Gelfoam cover was elevated to expose the arterial stump and a 3.0 figure-of-eight ligature of absorbable suture was precisely placed for control. The Gelfoam was replaced and the anastomosis performed.

13.5.4 "Modified Clipless Antegrade Nerve Preservation"

We used the Da Vinci three-arm system (Intuitive Surgical, Sunnyvale, Calif). Once we divided through the bladder neck, the previously dissected seminal vesicles and vasa deferentia were retracted anteriorly, exposing the posterior base of the prostate. The plane between both layers of Denonvillier's fascia was identified and developed, separating the prostate from the rectum. Once this plane has been dissected distally toward the apex of the prostate, the thick lateral pedicles of the prostate are visualized bilaterally. Using blunt dissection, the vascular pedicles were teased off the prostatic capsule, proceeding from the developed posterior plane in a medial to lateral direction and leading to the initial release of the vascular pedicles before the NVBs.

The vascular pedicles were further mobilized off the capsule of the prostate in an anterior direction until the most distal ends of the vascular pedicles were identified before penetrating the prostatic capsule. These small vessels were then cauterized at their most distal ends using only a bipolar device. The vascular pedicles were then swept off the prostate, further mobilizing the NVBs, which were then dissected sharply from the prostatic capsule. We continued the dissection, peeling off the periprostatic fascia, NVB, and prostate pedicle en bloc until the urethra was reached. The dissection was performed starting posteromedially at the base of the prostate, marching laterally and anteriorly, and then advancing distally, hence in an antegrade fashion [44].

During dissection, delicate handling of the tissue was used to minimize trauma. The pedicles were noted to be thick and therefore protected from the required traction needed to tease off the NVBs. The use of monopolar electrocautery and clips was avoided during this dissection. Slight venous bleeding was left uncontrolled and pulsatile arterial bleeds were precisely coagulated using a bipolar grasper. The urethra

was then sharply divided and the prostate removed using an endoscopic bag. The preserved NVBs and prostatic pedicles were clearly visible at this point.

13.6 Robotic Series: Sexual Outcomes

13.6.1 Weill Medical College (Cornell University) Experience

From January 2005 to May 2006, 324 men underwent robotic radical prostatectomy by a single surgeon (A.T.). Baseline demographic data was prospectively collected including age, race, body mass index (BMI), serum prostate-specific antigen (PSA), prostate volume, Gleason score, percentage cancer, TNM clinical staging, comorbidities, as well as IPSS and IIEF scores. Postoperative variables studied included fall in hematocrit, hospital days, and pathological stage, Gleason score and margin rates, PSA, duration of catheterization, urinary retention, complications, continence status, and sexual function. All patients completed confidential, self-administered questionnaires regarding erectile function (EPIC and IIEF) before and 1, 3, 6, and 12 months after surgery. Potency was defined as the return of erections firm enough for vaginal penetration (Table 13.2).

Table 13.2 Weill Medical College (Cornell University) experience ($n=324$). *BMI* body mass index, *PSA* prostate-specific antigen

Variables	Mean (median)	Range
Baseline parameters		
Age (years)	59.62 (58.64)	43.16–74.14
BMI	27.94 (27)	19–50
IPSS symptom	7.71 (5)	0–35
Serum (PSA) ng/ml	5.93 (4.8)	0.33–66.4
Pathological stage		
pT0	2 (0.61%)	
pT2a	54 (16.66%)	
pT2b	7 (2.16%)	
pT2c	226 (69.75%)	
pT3	32 (9.6%)	
pT4	3 (0.9%)	
Positive margins (overall)	24(10.25%)	
Potency outcomes (%)		
At 12 weeks	54	
At 6 months	69	
At 1 year	81	

We evaluated erectile function in patients who were potent preoperatively (erections sufficient for vaginal penetration) and who underwent nerve-sparing surgery (165); 93 of these had a 12 month follow-up, and of these, 75 (81%) were potent. The potency rate at 12 weeks was 54 and 69% at 6 months. A multivariate Cox proportional hazards regression analysis was performed to identify possible predictors for return of sexual function. The following risk factors were found to be significant: patient age ($p = 0.005$); nerve-sparing ($p < 0.001$); and preoperative IIEF scores ($p = 0.014$). The BMI did not impact potency.

13.7 Erectile Dysfunction After Radical Prostatectomy: Treatment Strategies

The management of ED after RP poses a few specific challenges. Unlike ED seen in the elderly, which is often a gradual process, patients who have undergone radical prostatectomy are recovering from the emotional trauma of having been diagnosed with prostate cancer, only to find that in the postoperative phase, the ED is sudden and in many cases severe.

13.7.1 Evaluation

A common problem seen with ED following RP is the wide variation in the incidence. Rates of ED ranging from 40 to 85% have been reported and return of erectile function maybe seen in 9–40% [47]. It has been difficult to define in exact terms as to what constitutes return of erectile function. Various studies have traditionally used the SHIM score for routine evaluation of erectile function, both in the preoperative and postoperative periods; however while reporting postoperative return of erectile function the SHIM scores are not uniformly used. Few authors use responses to specific questions on the SHIM as evidence of return of erectile function. We have relied more specifically on evidence of regular and periodic sexual activity, assisted or unassisted with oral drugs, but not augmented by injectable or intraurethral vasoactive agents, as the final evidence of return of erectile function.

13.7.2 Questionnaire-based Assessment

The SHIM is a subset of the larger and more detailed International Index of erectile function (IIEF). The International Index of Erectile Function (IIEF) is a widely used, multidimensional self-report instrument for the evaluation of male sexual function [48]. It has been recommended for evaluation of the severity of ED. It has been linguistically validated in other languages and has demonstrated consistent and robust treatment responsiveness in studies in the U.S., Europe, and Asia, as well as in a wide range of etiological subgroups [48]. A severity classification for ED has recently been developed, in addition to a brief screening version of the instrument. The IIEF has 15 questions (Fig. 13.1) encompassing various aspects of sexual function and each question is graded from 0 to 5. The total score possible is 75. Using this questionnaire, an

Table 13.3 Grading of erectile dysfunction based on SHIM scores

SHIM score	Erectile dysfunction (ED)
22–25	No ED
17–21	Mild ED
12–16	Mild–moderate ED
8–11	Moderate ED
5–7	Severe ED

abridged five-item version of the IIEF (IIEF-5/ SHIM) was devised [49]. The SHIM is a popular tool and is often used for the initial assessment and grading of ED (Fig. 13.2; Table 13.3).

13.8 Clinical Assessment of Patient with ED After Radical Prostatectomy

Many patients are disappointed when they find that they have ED after RP. Though older patients seem to be willing to trade-off urological adverse outcomes for a better 5-year survival in the setting of prostate cancer, and are more willing to accept an impotence outcome than a urinary-incontinence outcome [50], younger men are more disappointed with a loss of erectile function. The loss of erectile function imposed on a background of a recently diagnosed prostate cancer can have serious emotional and psychological adverse effects, which can on its own affect sexual function in these men. It is therefore essential to address these issues when evaluating these patients.

13.8.1 Nocturnal Penile Tumescence Testing

Nocturnal penile tumescence (NPT) testing with the use of erectometers is a good way to assess the functional aspect of erectile function and differentiate between organic and psychogenic dysfunction. The NPT recordings can be done in the early postoperative period after nerve-sparing radical prostatectomy and have shown residual erectile function as early as the first night after catheter removal. [51]. The NPT testing can also identify cases with little or no erectile function and help in treatment selection. Patients with minimal erectile function can suffer long-term effects of continued penile ischemia and loss of cavernous smooth muscle with its consequences such as progressive fibrosis, smooth muscle dysfunction, and ultimately venoocclusive dysfunction [52].

13.8.2 Duplex Doppler Assessment

Studies done in patients undergoing nerve-sparing RP suggest a vascular mechanism in the genesis of post-RP impotence. This mechanism has been shown to be arterio-

genic (surgical loss of accessory pudendal arteries) and can be unilateral or bilateral; it could be due to venous leak and there could be a mixed pattern with both arterial and venous components [53]. Criteria for normalcy during Duplex Doppler Ultrasound include a peak systolic velocity of 30 cm/s or greater and an end diastolic velocity of 5 cm/s or less [52]. The patient is considered to have arteriogenic insufficiency when the peak systolic velocity is less than 30 cm/s, venous leakage when the end-diastolic velocity is more than 5 cm/s, and a mixed pattern when he has both [52].

13.8.3 Dynamic Infusion Cavernosometry and Cavernosography

Dynamic infusion cavernosometry and cavernosography (DICC) is not a widely performed procedure for evaluating ED. Although less-invasive methods of evaluation, such as NPT monitoring and penile duplex Doppler ultrasonography are often chosen, they may not correlate with the occurrence of venous leakage [54]. The most important utility of DICC is in the diagnosis of, and in the identification of, the location of venous leakage. The procedure includes the use of papaverine and intracavernous infusion through butterfly needles to maintain penile turgidity. The flow rate to maintain pressures and the decay of pressures is noted. If the flow to maintain is greater than 3 ml/min or the pressure decay of more than 45 mmHg, the patient is mostly likely to have venous leakage [52]. Cavernosography is done by infusing a contrast medium and assessing the presence of leakage by using fluoroscopy with oblique views. Leakage, if seen, is documented by taking X-rays and is graded.

13.9 Treatment

13.9.1 Phosphodiesterase-5 inhibitors

Montorsi et al. showed that early use of intracavernous injection of Alprostadil resulted in better recovery rate of spontaneous erections after nerve-sparing radical retropubic prostatectomy [55]. This paved the basis for using oral phosphodiesterase-5 (PDE5) inhibitors, which were shown to improve rates of return of erectile function after RP. These drugs work by improving cavernous oxygenation, thereby limiting the development of hypoxia-induced tissue damage.

13.9.1.1 Sildenafil

Early treatment is thus aimed at minimizing cavernous hypoxia by the active use of PDE5 inhibitors. All patients who undergo RP are now routinely started on a dose of 50–100 mg of sildenafil daily or on alternate days. The Cleveland Clinic in their initial study found that 52% (48 of 91) of post-RP patients responded to sildenafil. Patients who underwent bilateral nerve-sparing surgery had a better response than patients who underwent unilateral or non-nerve-sparing surgery [56] and in a subsequent study showed that most patients who initially respond to sildenafil continue to use the drug long term [57].

13.9.1.2 Vardenafil

Vardenafil is another newly approved PDE5 inhibitor that has been shown to be effective for the treatment of ED. In a randomized, placebo-controlled, double-blind, multicenter trial by Brock et al. treatment with vardenafil significantly improved erectile function and had mild-to-moderate headaches, flushing, and rhinitis as side effects [58]. Nehra et al. reported that vardenafil 10 and 20 mg were significantly superior to placebo for intercourse satisfaction, orgasmic function, and overall satisfaction with sexual experience [59]. The most common adverse effects of vardenafil were headaches and rhinitis. The discontinuation rates due to adverse effects were higher in the vardenafil group than in the placebo group (3–4 vs 1%) [59].

13.9.1.3 Tadalafil

Tadalafil is a long-acting PDE5 inhibitor that has been shown to be effective, safe, and well tolerated in the treatment of ED [60]. It has a long half-life and the fact that food does not delay its absorption are two important advantages. Tadalafil was effective up to 36 h after dosing and was effective regardless of disease severity and causes, and in patients of all ages. The most frequent adverse events were headache, dyspepsia, back pain, and myalgia [60].

13.9.2 Intracavernosal Injections

Intracavernous injections work by local stimulation of the erectogenic mechanism, by causing vasodilation and therefore an increased inflow. Intracavernous therapy works best when the cause of ED is of a nonarteriogenic etiology. The commoner neurogenic etiology seen after RRP is very amenable to treatment with this modality. The commonly used vasodilator agent Papaverine acts by nonspecific inhibition of PDE. More recently, prostaglandins (PGE1) analogs, such as alprostadil, are available for use both intracavernously as well as intraurethrally. A combination of three agents called Trimix (papaverine, phentolamine, and PGE1) is also available and considered very potent.

Side effects and the need to self-inject is a major reason for compliance-related issues with intracavernous injections. Overall, 69 of 102 patients (68%) in one study achieved and maintained erections, but only 48% continued long-term therapy. Intracavernous therapy forms an excellent salvage option for patients with ED who fail oral therapy after RP [61]. The main reasons for dropout in another large study were cost of therapy, patient and partner problems with the concept of penile injection, lack of partner availability, and spontaneous improvement in erections. Lack of efficacy of therapy was the primary reason for only one of seven dropouts. Furthermore, adverse effects of penile injections (priapism, penile nodules, pain) appeared to be only minor contributors to dropout [62].

Another way to deliver PGE1 to the cavernous tissue is by way of using an intraurethral pellet – the medicated urethral system for erection. The main side effects seen after MUSE included dizziness, sweating, and hypotension in 5.8% with syncope in 1% of cases. Urethral bleeding after MUSE application was observed in 4.8% of cases [63].

13.9.3 Vacuum Constriction Devices

Vacuum constriction devices (VCD) work by creating a vacuum around the penis, drawing blood into the corpora cavernosa. Constricting rings are placed at the base of the penis, causing a trapping of blood and thereby tumescence. Early trials showed good results and almost 70% used the device regularly. The patient and partner satisfaction was 82–87% [64].

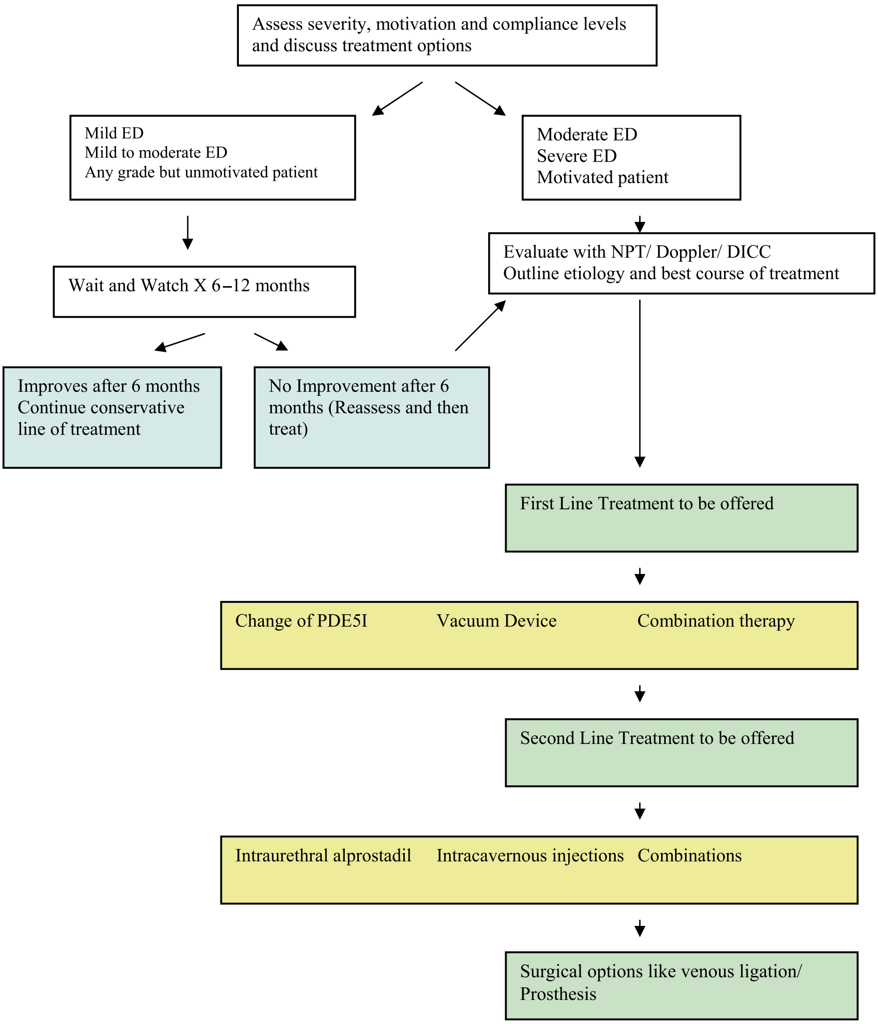

Fig. 13.11 Algorithm for managing patients with erectile dysfunction after radical prostatectomy (sildenafil nonresponders). Erectile dysfunction identified by patients administered IIEF/ SHIM and by third-party phone calls. *NPT* nocturnal penile tumescence, *DICC* dynamic infusion cavernosometry and cavernosography

The VCD may have a special role in ED after RRP since it is relatively less cumbersome than intracavernous injections and may have a higher compliance rate. Even in an era of effective oral medication, the vacuum erection device remains a preferred treatment option for a substantial number of patients with ED [65].

13.9.4 Combination Therapy

Various combinations of treatment can be used. Men not entirely satisfied with erectile function after separate uses of sildenafil or a vacuum entrapment device (VED) are usually given more invasive alternatives; however, Chen et al. found that combination of sildenafil and a vacuum constriction device resulted in greater satisfaction, as documented by a significant improvement in IIEF scores, compared with either agent alone [66]. Combined use of sildenafil and a VED may be offered to patients not satisfied when either treatment is used alone.

Other combinations include PDE5 inhibitors with alprostadil, and intracavernous injections and PDE5 inhibitors.

13.10 Treatment Protocol for the Patient with ED After RP

We feel that in the treatment of patients with ED after RP, good communication with the patient regarding treatment options is very important. The chances of response are greatest for the patient who expresses satisfaction with his decision to undergo surgery, is continent, and has mild-to-moderate ED. He should be motivated and be willing to comply with the treatment. It helps even more when he has a supportive partner.

The first line of treatment is with PDE5 inhibitors. Depending on the response, we wait at least 6–12 months before offering more invasive forms of treatment. The protocol is summarized in Fig. 13.11.

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Chapter

14 Robotic Pyeloplasty

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14.1 Introduction

Laparoscopic pyeloplasty (LAP) for uretero-pelvic-junction obstruction (UPJO) was introduced by Schuessler et al. in 1993 [14]. The procedure has since been a staple of the urological practice with several large series confirming its feasibility and yielding functional results comparable to those of open procedures [8]. Peters and coworkers [13] were also able to show the feasibility of LAP in pediatric patients. Despite proving less traumatic and more patient friendly, LAP for UPJO never achieved widespread adoption, due to the procedure's demanding technical requirements, its strain on operator ergonomics, and the limitations imposed by the challenging intracorporeal anastomosis suturing [1]; however, with the advent of telerobotic surgery, such limitations were rendered less of a hindrance, due to the versatile nature of systems such as the Da Vinci system (Intuitive Surgical, Sunnyvale, Calif.) which offers greater degrees of freedom thus making robotic assisted pyeloplasty (RAP) a viable option and alternative to LAP. In order to stand the test of time, the surgical outcome of both techniques has to be compared with the success rates of the classical open dismembering Anderson–Hynes procedure, the gold standard for pyeloplasties [9]. Recent studies [2, 5] have shown that dismembering gives superior results in the long term and therefore other non-dismembered procedures, such as the Y-V plasty or other flap plasties, should only be used in selected cases such as cases of the dependent uretero-pelvic junction (UPJ), or imminent surgery at the uretero-vesical junction, for fear of compromising the ureter's blood supply.

There is an ongoing debate as to whether the pelvis should be accessed by a retro- or transperitoneal approach. At the authors' institution RAP is routinely performed via a retroperitoneal approach [10], and although the transperitoneal approach seems to be more familiar to most laparoscopic surgeons, the procedure has a longer operating time when compared with the retroperitoneal approach [8] and carries the inherent risk of injury to intraperitoneal organs and structures. Orientation in the retroperitoneum is also an issue, as there are few recognizable landmarks for guidance and it can be especially difficult in obese patients. Additionally, the space is limited, making correct port placement for the robotic arms vital, and it should be done with the utmost caution. For the horseshoe kidney transperitoneal access is undoubtedly favored [3]; however, pyeloplasty on these kidneys can be done through a retroperitoneal approach [10].

14.2 The Retroperitoneal Approach

14.2.1 Patient Preparation and Positioning

In principle, the same rules for patient preparation as in standard LAP apply. We do not find a need to diagnose an aberrant vessel before the procedure since it has no influence on our approach. In infants, children, and adolescents general anesthesia is induced before placement of a sacral/epidural catheter, which is left in place for 18–24 h postoperatively, whereas in adults the epidural catheter is inserted under local anesthesia before induction of general anesthesia. An indwelling catheter is placed in all cases. The pneumatic development of the retroperitoneal space seems to cause pain for a few hours postoperatively, and is easily counteracted by the epidural anesthesia.

Although some surgeons prefer to place a ureteral stent [8], we proceed directly to place the patient in a flank/semiprone position (Fig. 14.1). Infants and children are placed on a small gel sandbag positioner placed under the contralateral iliac crest. The upper leg is extended, while the lower leg is flexed to about 90° at the hip and the knee, and the legs are padded with an auxiliary gel cushion to decrease undue stretch and to avert pressure sores in prolonged procedures. Excessive internal rotation of the upper leg should be avoided especially in older patients, as this might be hazardous for the hip joint. Arms are secured in the "praying position" or are placed stretched and padded on an arm board. The patient is then secured to the table with safety belts or tensoplast. Children and lean adults can be placed diagonally on the table (Fig. 14.1), a maneuver that facilitates subsequent positioning of the robot. Adult and adolescent

Fig. 14.1 Placement of children and young adults on the operating table for retroperitoneal access. Note the stretched upper leg and the flexed lower leg

patients should be placed with their waist on the kidney rest and the operating table should be flexed in order to open the costovertebral angle. Too much flexion decreases the anterior–posterior space in the retroperitoneum and is unnecessary as the robot does not need much working space between the costal margin and the iliac crest.

14.2.2 Retroperitoneal Access and Port Placement

Once the patient has been draped, port placement ensues, and since only few instruments are necessary for this, the scrub and floor nurses can proceed with black/white balance and calibration of the system while the surgeon and an assistant place the ports, thereby saving valuable time.

The first 15- to 20-mm skin incision is made one finger breadth above the iliac crest just posterior to the anterior iliac spine (Fig. 14.2). The external fascia is incised and the muscles are split by blunt dissection under direct vision with small retractors. The lumbodorsal fascia is incised sharply and with the index finger a *small* retroperitoneal recess is developed posterio-cranially. It is at this crucial stage that the peritoneum is not to be violated.

In adults and older children, a commercial dilating balloon trocar is inserted and the retroperitoneal space is dilated with 400–500 ml air. In infants and some children, commercial trocars are too large and should be replaced by a homemade dilating balloon catheter, which is easily concocted by securing the "cut middle finger" of a size 8 latex surgical glove to a 12- to 14-F catheter with a 3-0 ligature. Dilation should be done slowly to avoid tearing the peritoneum. The balloon is in the right position if the abdominal wall bulges medial to the trocar during balloon expansion. The balloon

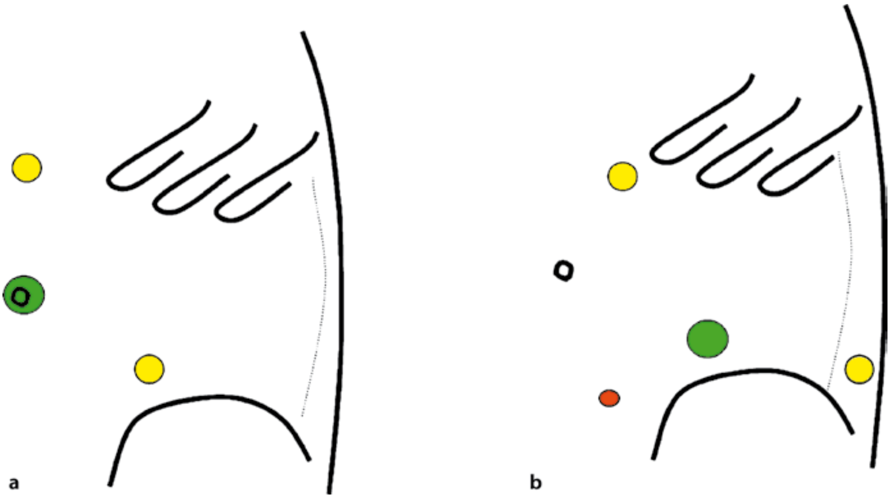

Fig. 14.2 Port placement with the transperitoneal (**a**) and retroperitoneal (**b**) access. Camera port (12 mm): *green*; instrument port (5–8 mm): *yellow*; optional port for assistance (5 mm): *red*. (From [17])

should remain inflated in situ for 5 min. In the meantime 2-0 sutures are placed at either end of the external fascia and skin incisions leaving enough space for camera port placement in-between. The sutures are secured with clamps and should not be knotted at this point.

The first 8-mm instrument port is placed under digital guidance just medial to the edge of the latissimus dorsi muscle and two finger breadths above the iliac crest. The medial 8-mm instrument port is placed just below the costal margin in the anterior axillary line. All fat and the peritoneal fold should be swept medially by finger dissection before port placement. The trocar should be cleaned for surrounding fat and tissue from the inside and not inserted more than 1 cm to keep a proper working space for the instruments. An optional 5-mm port for assistance, suction, and suture delivery is inserted in the right or left iliac fossae. We use blunt trocars through 70 mm radially dilating sleeves, instead of the original cutting trocars of the Da Vinci system. This diminishes the risk of bleeding and tissue/organ injury.

Finally, an air-tight balloon tipped trocar is used in the primary incision for camera access. The balloon retains the tip of the trocar in the retroperitoneum, preventing it from retraction in between the abdominal muscle layers; however, this trocar can only be used in slim adults and children, since the camera arm of the Da Vinci system needs at least 15 mm of free trocar shaft to be fixed. In patients with a thicker muscle or fat layer a standard 12-mm blunt trocar should be used. After satisfactory placement of the balloon-tipped trocar, it is secured by knotting the sutures previously placed in the fascial and skin edges.

14.2.3 Docking of the Surgical Cart and Placement of Instruments

The crucial point of the retroperitoneoscopic access is the correct placement of the surgical cart. The cart is wheeled in a 45–60° angle from the patient's head (Fig. 14.3.) depending on the expected localization of the UPJ. The cart should be placed as closely as possible to the patient with the camera arm pointing toward the upper pole of the kidney. The carbon dioxide supply is connected and the pressure is set to 8–10 mmHg, which is slightly lower than pressures needed for transperitoneal access.

As soon as the 0° telescope is inserted, Gerota's fascia is recognizable. Condensation on the telescope, caused by low telescope temperature and the small retroperitoneal space, may blur the initial view but tends to disappear spontaneously within a few minutes once temperatures have equilibrated. Depending on surgeon preference and handedness, a DeBakey grasper is inserted through the left instrument port and a cautery hook (alternatively: monopolar cautery scissors) is inserted through the right. The correct placement of the assistant port is verified by inserting an instrument into the field of vision. Especially in children, the working space is limited. Here the surgeon can take advantage of the wrist function of the instruments instead of moving the arms extensively, the latter with a risk of collisions between the arms.

14.2.4 The Procedure

Once Gerota's fascia has been identified, it should be opened alongside and about 2 cm from the quadratus lumborum muscle. It is important to make a long cranio-caudal

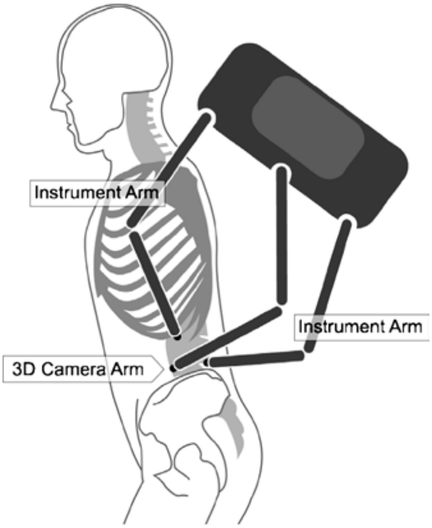

Fig. 14.3 Placement of the surgical cart at a 45–60 degree angle from the patient's head

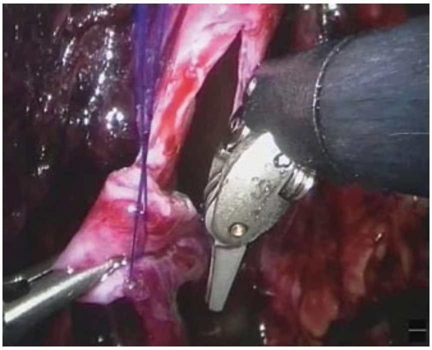

Fig. 14.4 Dismembering of the uretero-pelvic junction. Note stay suture in the pelvis and proximal ureter keeping urine and blood out of the operative field. The left kidney is exposed from behind through a retroperitoneal access

opening which enables the kidney to fall medially. As soon as the lower kidney pole is identified and freed, further dissection medial to the quadratus lumborum and psoas muscles will expose the ureter and the pelvis. On the right side the vena cava will appear laterally. The UPJ is mobilized; an aberrant vessel should be identified and, if present, carefully dissected. Subsequent steps do not differ from those of a standard Anderson–Hynes procedure; however, to stabilize the ureter and the pelvis during the anastomosis, two stay sutures are brought into the retroperitoneal space by a straight needle from the outside at the costovertebral angle (Fig. 14.4). The first stay suture is placed in the pelvis just cranial to the planned resection line. The second stay suture is placed at the upper end of the ureter preferably through the stenotic area which should first be excised at the termination of the anastomosis as it can be used as handle. Other than stabilizing the ureter and pelvis, suspension with stay sutures allows continuous drainage of blood and urine away from the anastomotic line, thereby improving

overview. The pelvis is opened with scissors and, if necessary, reduced. The ureter is spatulated 1–2 cm past the stenotic area.

When an aberrant vessels is encountered, the ureter should be brought anteriorly so that the final anastomosis will lie in front of the vessel. In these cases the stay suture at the upper end of the ureter should be placed first, immediately after completing dismemberment. As in all kinds of surgery, it is wise to start with the difficult part of the anastomosis, i.e., the anterior suture line. The anastomosis is done with interrupted or with running sutures, depending on the surgeon's preference. In infants and smaller children, we prefer a polyfilament resorbable 6-0 suture on a round needle, whereas a 5-0 suture is more appropriate in older children and adults. Monofilament sutures have too much memory making their handling more difficult. When suturing, the scissors in the right instrument arm should be exchanged with a large needle holder, keeping the DeBakey instrument on the left hand side. All contact with the mucosa should be avoided during the opening and reduction of the pelvis as well as when suturing, in order to prevent swelling and edema which ultimately complicates matters.

Stent placement is optional; however, it is routinely done at the author's institution. When a JJ stent is to be placed, it should be inserted as soon as the anterior anastomosis has been completed. The guide wire can be brought inside through the assistant port and from there guided down the ureter by the operator using the DeBakey forceps and the needle holder. The JJ size choice depends on the estimated length of the ureter. For optimal placement, it is advisable with a controlled insertion. This is done by the assistant, who, as soon as the tip of the guide reaches the upper open end of the ureter, feeds a measured length of the guide, a little longer than the actual length of the JJ stent. This ensures that the JJ catheter reaches the bladder but does not go beyond it. Countertraction is exerted on the JJ stent by a semiclosed DeBakey forceps while the guide wire is removed in order to keep the stent in place. Alternatively, the JJ catheter can be placed before the procedure, although this makes the anterior anastomosis more difficult and prolongs the theater time.

As soon as the JJ stent has been placed, the posterior part of the anastomosis and, if necessary, the pelvic defect, are closed. After removing the stay sutures, the UPJ falls back to its original position and the carbon dioxide is exsufflated. The surgical field is observed for venous bleeding and thereafter the surgical cart and the ports can be removed.

We leave a drainage tube overnight only if there is a significant incongruence in the thickness of the ureteric and pelvic walls. The external fascial layer at the camera port and, if necessary, at the instrument ports, are closed with a single (2-0)–(4-0) suture and the skin is closed with a subcuticular running suture, especially in children. If the patient is doing well, we remove the sacral/epidural catheter the next morning and the bladder catheter 6 h later.

14.3 The Transperitoneal Approach

14.3.1 Patient Preparation and Positioning

Patient positioning on the table is quite similar to that of the retroperitoneal access with the patient in flank position of 70–90°. Obese patients should be placed close to the

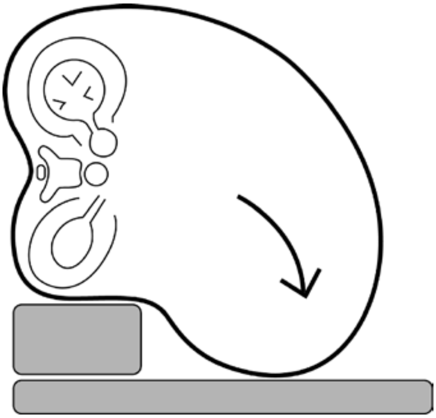

Fig. 14.5 Placement of obese patient on a pillow allows the pendulous abdomen to fall down

edge of the table or the patient should be placed on a pillow allowing the pendulous abdomen to fall down (Fig. 14.5). This makes access to abdominal cavity more convenient. Extensive flexion of the table should be avoided. As in the retroperitoneal approach this reduces the abdominal anterior–posterior diameter and thereby the working space.

14.3.2 Transperitoneal Access and Port Placement

Pneumoperitoneum is established in the usual way in adults and adolescents with Verre's cannula, while the access should be done by open dissection in infants and children. In the latter case the camera port is placed just above or below the umbilicus (Fig. 14.2), and in older patients the camera is placed lateral to the rectus abdominis muscle at the umbilical level in the midclavicular line. One 8-mm instrument port is placed 10–15 cm cranially, the other in the iliac fossa under visual guidance. A 5-mm assistant port for providing suction and needles should be placed in the lower midline, if needed. On the right side a 5-mm port for a grasper catching the inner thoracic wall can be used as a retractor for the liver.

14.3.3 Docking of the Surgical Cart and Placement of Instruments

The surgical cart should be placed close to the patient from the back at an angle of 70–90° to a crandio-caudal axis. A 30° telescope is inserted through the camera port, assisted by a cautery hook and a DeBakey forceps.

14.3.4 The Procedure

Initially the colon is mobilized laterally. On the left side care is taken to prevent tearing of the gastric vasa brevia. In children and slim adults sometimes the dilated pelvis can

be seen through the mesocolon and can be approached from there directly without the mobilization of the colon. The remaining procedure is essentially the same as in the retroperitoneal access (see above). Stay sutures in the proximal ureter and the pelvis are placed more anteriorly through the abdominal wall. The stay sutures are fixed outside the abdomen with small clamps, which allows changing the traction on ureter and pelvis during the procedure.

Some authors prefer the transperitoneal approach because they believe that aberrant vessels are easier recognized [6], whereas others argue that lifting the lower pole nearly always reveals the aberrant vessels in the retroperitoneal approach [8]. Using the transperitoneal approach requires use of a drainage tube, placed through the assistant port site, and should be left in place until the anastomosis has proved tight after removal of the bladder catheter on the first postoperative day.

14.4 Follow-up

We remove the JJ stent after a period of 4–6 weeks, although this time period is based on very little evidence. The patients are followed with ultrasonography and MAG3 renography, 3 and 12 months after the operation.

14.5 Surgical Outcome

Defining results in pyeloplasties has always been subject to much debate. While some define outcome based on radiological end points such as appearance and "function" on CT scan or intravenous urography (IVU), others rely on outcome measures such as renographic wash-out curves, scintigraphic stable, or increasing differential function (DF) or decreasing AP diameters on sequential ultrasonography. The pitfalls of the renographic assessment are well described [4] and make this method doubtful in cases with pronounced dilation. In all cases, the necessity of a repeat pyeloplasty can only be considered a failure and may be the one hard end point agreed upon by all. Even recurrent pain has not been defined as a single criterion of failure, since a small group of patients have persistent symptoms without any signs of obstruction on renography or ultrasound. This makes the outcome difficult to assess in nonrandomized studies; however, open dismembered pyeloplasties are considered the gold standard in treating UPJO [9] and any new treatment modality should be benchmarked against it.

14.5.1 Operative Time

The main surgical outcome measures of larger series [6, 7, 10, 11, 16] are listed in Table 14.1. There seems to be a tendency towards shorter operative times in younger patients and children and with the retroperitoneal access; however, "operative time" is often a vague term more often than not lacking uniformity between studies. For example, some studies include the endoscopic placement of a ureteric catheter which adds 20–30 min to the operative time. For fairly trained laparoscopists there seems to be no difference between a laparoscopic or robotically assisted pyeloplasty [8, 16].

Table 14.1 Surgical outcome of robotically assisted pyeloplasties in recently published larger series. *RAP* robotically assisted, *LAP* laparoscopic, *OPN* open procedure, *NA* not applicable

Reference	Number	Age (mean; years)	Technique	Access	Operative time (mean; range)	Dismembered (%)	Crossing vessel (%)	Success rate (%)	Follow-up (months; range)
[7]	RAP 32	61.2 (6–67)	RAP	Transperitoneal	300 (120–510; includes cystoscopy)	100	44	100	8.6 (1.5–16)
[11]	RAP 35	39 (15–69)	RAP	Transperitoneal	216.4 (±52.9)	100	NA	94	7.9
[16]	LAP 14	LAP 24.5 (8–64)	LAP vs RAP	Transperitoneal	LAP 299 (193–376)	LAP 64	LAP 50	LAP 100 (64)[a]	LAP 10 (1–31)
	RAP 31	RAP 26 (10–60)			RAP 271 (207–444; includes cystoscopy)	RAP 87	RAP 74	RAP 97 (67)[a]	RAP 6 (1–21)
[12]	RAP 50	31 (16–62)	RAP	Transperitoneal	122 (60–330)	100	30	100	11.7 (1–28)
[6]	OPN 33	OPN 7.6 (0.2–19)	OPN vs RAP	Transperitoneal	OPN 181 (123–308)	OPN 100	OPN 83	OPN 100	OPN 20 (1–57)
	RAP 33	RAP 7.9 (0.2–19.6)			RAP 219 (133–401)	RAP 100	RAP 50	RAP 97	RAP 10 (0.4–28)
Olsen et al. [10]	RAP 67	7.9 (median; 1.7–17.3)	RAP	Retroperitoneal	146 (93–300; median)	88	22	94	35.8 (1.3–57.9)

14.5.2 Success Rates

O'Reilly et al. [9] assessed the long-term result of open dismembered pyeloplasties 6–19 years after surgery and found success rates of 96% defined as improvement of drainage on renography. The short- and median-time follow-up results of RAP in larger series are shown in Table 14.1. They seem to be reasonable taking into account the novelty of the technique and the fact that these results include a learning curve. As in LAP, overlooked aberrant vessels were the reason for failures and repeat pyeloplasties in the majority of cases [6, 8, 10, 15].

14.5.3 Complications

In contrast to laparoscopic nephrectomies, bleeding does not seem to be a major problem in RAP. Most reported postoperative complications are urinary tract infections or problems relating to the JJ catheter such as blockage due mainly to blood clots[10]. This can be avoided by meticulously washing out the renal pelvis before placing the last sutures of the anastomosis. There does not seem to be distinct robot-related complications; however, in smaller children the ports are very close to each other and can give rise to collisions between the arms. In addition, the flexibility of the camera arm is limited and correct placement of the camera port is crucial. One should plan the placement prior to surgery based on available imaging. In our series [10] we converted to open surgery in one patient, since the UPJ could not be visualized in a patient with a huge hydronephrosis. No serious complications have been reported thus far in the literature.

14.6 Conclusion

The RAP is a feasible procedure with long-term results and complications comparable to those of open surgery. The transperitoneal approach is the most popular but seems to take longer time than the retroperitoneal approach. Robot-related expenditures are high and include the initial investment premium and significant running costs. This makes RAP expenditures surpass those of standard laparoscopic pyeloplasty [16], but since the laparoscopic procedure is much more difficult to train than the RAP, minimally invasive pyeloplasty will be available to a larger group of patients especially with the dissemination of RAP due to the demand of surgeons and patients. Ultimately high costs may eventually become less of an issue as the increasing demand and projected competition may in due course lead to more reasonable prices. Alternatively, the creation of centers of excellence may be the way forward in reducing costs per case.

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Chapter

15

Robot-assisted Radical Cystectomy

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Peter Wiklund

15.1 Introduction

In the United States, 63,000 new cases of bladder cancer will be diagnosed on a yearly basis as estimated by the American Cancer Society; of them, more than 20% will die of this disease. The incidence of bladder cancer is higher in men than in women, and it is the fourth most common cancer in men after prostate, lung, and colorectal cancer [1]. In the western world the most common etiological factors are cigarette smoking and occupational exposure to various chemicals. Treatment of bladder cancer ranges from transurethral resection of superficial bladder tumors to radical cystectomy with extensive lymph node dissection in combination with neoadjuvant chemotherapy in muscle-infiltrating cases.

Muscle-invasive urothelial urinary bladder cancer has a very high mortality rate, regardless of intensive therapeutic efforts such as radical surgery in combination with oncological treatment options. More than 50% of the patients do not survive 5 years of follow-up time, calculated on the whole bulk of muscle invasive tumors ranging from T2 to T4. In case of intraoperatively diagnosed dissemination of the cancer to regional nodes the prognosis is even worse with, 75% of the patients in this subgroup (pN1–pN2), being deceased within 3 years [2, 3].

Cystectomy performed through a laparoscopic approach was first described in 1992 [4]; however, due to relatively difficult technical problems, this treatment is still considered experimental. The introduction of robot-assisted surgery for pelvic laparoscopy, especially in performing radical prostatectomy, is starting to change the possibilities of performing complicated operations in the pelvis. Three-dimensional vision with tenfold magnification and the dexterity provided by the EndoWrist (Intuitive Surgical, Sunnyvale, Calif.; six degrees of freedom) allows the surgeon to operate the tips of the laparoscopic instruments like an open surgeon [5]. The surgeon will benefit from a faster learning curve as compared with that of conventional laparoscopy. These advantages have allowed surgeons to translate standard open surgical techniques to a minimally invasive procedure, especially its potential in operating in a narrow pelvis as well as reconstructing a urinary neobladder. The obvious next frontier in the field of pelvic oncological surgery is likely to be the utilization of the robotic assistance in cystectomy and intracorporeal creation of urinary diversion. Several series have described the possibility of laparoscopic cystectomy using conventional laparoscopy combined

with extracorporeal construction of the neobladder via a mini-laparotomy [6, 7], and multiple centers in North America and Europe have already started to use the robot for surgery in operable advanced bladder cancer [8, 9]. In contrast to laparoscopic radical prostatectomy, the numbers of such robotic series are still limited; however, various technical procedures have been described concerning both the radical cystectomy (radical cystoprostatectomy, nerve-sparing and prostate-sparing cystectomy, and anterior excentration) and the type of urinary diversion (ileal conduit, continent pouch, and neobladder). Benefits include decreased blood loss and decreased pain, which would finally translate into early recovery and quick return to normal activities especially in patients with perioperative morbidity including the obese and elderly [10]. Studies are in progress to assess benefits in decreased fluid losses, which is a direct result of operating on a closed abdominal cavity.

15.2 Patient Selection

Although radical cystectomy has well-recognized risks of perioperative complications and its mortality, no alternative treatment has been efficacious with minimal morbidity. In the elderly, the ability to comply with stress is reduced and there is a marked reduction in functional reserve. Patients with incidence of significant comorbid conditions should be cleared after consultation with the specialists in medicine especially for their cardiopulmonary status. In our opinion, patients who should avoid a robotic approach are patients with decreased pulmonary compliance that would not tolerate steep Trendelenburg position. Furthermore, patients with a history of previous extensive abdominal surgery may be a relative contraindication. In our experience, patients with spinal stenosis may also be at risk to develop increased neurological symptoms after long procedures in the Trendelenburg position.

15.3 Preoperative Preparation

After risks, benefits, and complications of all treatment options are explained, informed consent is obtained. All patients undergo a mechanical bowel preparation and are started on a clear liquid diet 24 h prior to surgery. In the preoperative area broad-spectrum intravenous antibiotics are given and a stoma site is marked. Bilateral sequential compression devices are placed. After induction of general endotracheal anesthesia, a nasogastric tube and urinary catheter are inserted. The patient is placed in lithotomy position with arms adducted and padded. The table is placed in (25–30°) Trendelenburg position. Low molecular weight heparin (4000 units) is administered preoperatively and until the patient is mobilized (14 days). Shoulder pads should be avoided due to high risk for plexus damages.

15.3.1 Equipment

The technique is challenging, requiring conventional laparoscopic infrastructure as well as a highly skilled assistant in conventional laparoscopy. Standard laparoscopic

surgical equipment with some extra instruments are required (Ligasure, Tyco, Norwalk, Conn.), surgical endoscopy clip applicators 5–10 mm, laparoscopy bags, and laparoscopy stapler for intestinal stapeling).

15.4 Port Placement

A six-port transperitoneal approach is utilized after a pneumoperitoneum is created with a Veress needle. The Veress needle is inserted at the primary supraumbilical area for the camera port. Supraumbilical position is preferred to stay proximal to the urachus. This helps in performing an easier dissection of proximal ureters and an optimal approach for an extended lymph node dissection. A pneumoperitoneum of 12 mmHg is utilized during the case, although a higher pressure of 20 mmHg is helpful in providing additional abdominal wall tension while inserting the ports. Once the peritoneal cavity is insufflated, the Veress needle is replaced with a 12 mm camera port. We prefer a 30° up lens for inserting ports as it provides clear and direct visualization of the anterior abdominal wall, although a 0° lens can also be used. The second (right) and third (left) robotic arm ports (8 mm) are placed a centimeter below the camera port, just lateral to the respective rectus muscles bilaterally and symmetrically. The fourth port (12-mm right assistance port) is placed approximately 5 cm above

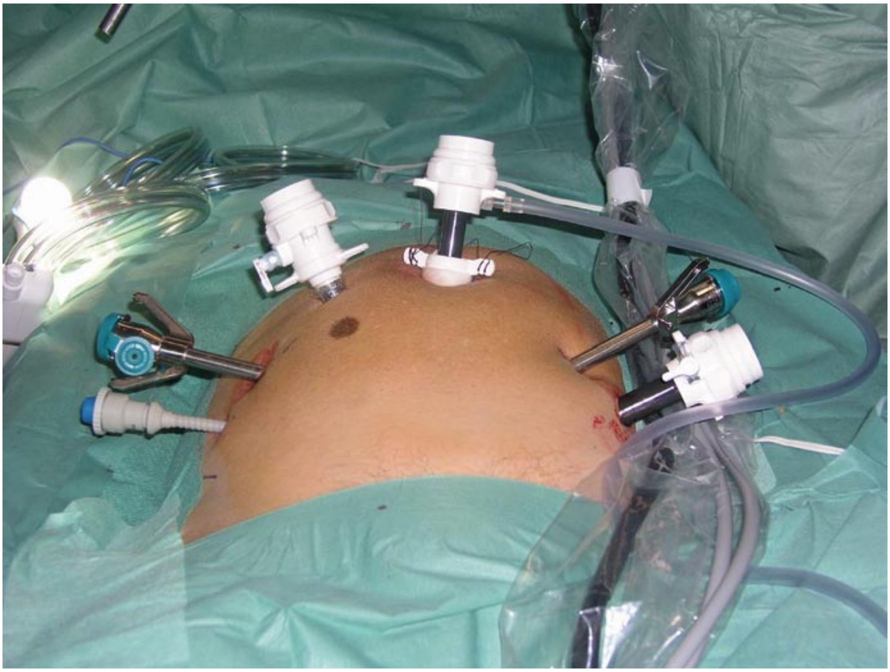

Fig. 15.1 Final position of port placement

the right anterior superior iliac spine in the mid-axillary line. The fifth (8 mm) port is positioned approximately 5 cm above the left anterior superior iliac spine for the insertion of the fourth robotic arm instrument. It is always important to make sure the fourth arm port and the left robotic arm port are not in the same alignment to avoid clashing of the robotic arms. The sixth (5 mm) assistant port is placed midway between the right robotic arm port and the camera port approximately 2.5 cm above the camera port. After all the ports are inserted, the robot is docked and the 0° lens is used for the initial procedure. Careful inspection of the peritoneal cavity for adhesions and metastasis is performed before the start of the actual procedure. When intracorporeal construction of the urinary diversion is performed, the fourth arm port is replaced by a 12-mm port from where the laparoscopy stapler for the intestinal stapeling is inserted. Figure 15.1 shows the final position of port placement.

15.5 Identification and Dissection of Ureters

After evaluation of the pelvic anatomy, the ureters are dissected proximally after tracing their peristalsis across the common iliac arteries. Adequate periureteric tissue is preserved in an effort to maintain generous vascular supply. Excellent visualization with gentle handling of periureteric tissue allows for less trauma or traction, thereby decreasing the risk of ureteral strictures. After dissecting the ureters distally to the ureterovesical junction they are clipped and divided using Weck clips (Hemo-lock, Weck Pilling, N.C.). The distal margins are sent for frozen section. A stay suture may be used at the distal end of the left ureter in order to facilitate the mobilization of the left ureter under the sigmoideum.

15.6 Male Cystectomy

15.6.1 Posterior Dissection

In the male patient the dissections start by mobilization of the ureters after which the dissection starts in the plane behind the seminal vesicles. The posterior dissection starts at the level of the Douglas pouch. A 6- to 8-cm incision is made through the peritoneum and the bladder is lifted vertically by the second assistant. The ampullae and the seminal vesicles are exposed but not dissected from the bladder if a non-nerve-sparing procedure is performed. The posterior aspect of the Denonvillier's fascia is exposed and incised horizontally to expose the prerectal fat. The dissection is continued on the anterior aspect of the rectum in a fashion identical to that of a radical prostatectomy. A tunnel is created between the rectum and the prostate with the neurovascular pedicles laterally.

15.6.2 Lateral Dissection of the Bladder

The medial umbilical ligaments are identified close to the abdominal inguinal ring. The peritoneum is incised lateral to the ligaments and the incision is performed to the

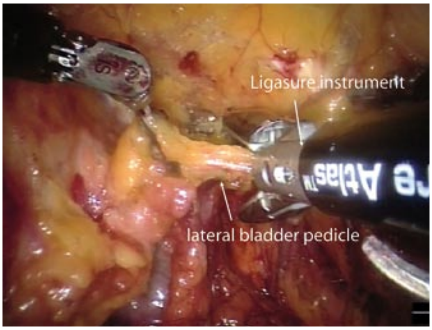

Fig. 15.2 Dissection of the lateral bladder pedicle by the use of a 10-mm Ligasure (Tyco healthcare) instrument

medial aspect of the external iliac artery. The vas is divided to open the space medial to the external iliac vessels. At this point the umbilical ligaments and the urachus are divided at the top of the bladder. The Retzius space is opened and the bladder is dissected from the anterior abdominal wall. This is performed with a combination of sharp and blunt dissection. The dissection is carried down to the posterior aspect of the symphysis. The space between the lateral wall of the bladder and the pelvic sidewall is developed until the endopelvic fascia is reached on both sides. The superficial dorsal vein is divided on the anterior aspect of the prostate and the endopelvic fascia is opened. The lateral surface of the prostate is separated from the levator ani muscle. The prostatic apex and the dorsal vein complex is thus isolated. The second assistant may now lift the bladder at the top and the lateral pedicles can be taken down by a 5- to 10-mm Ligasure (Tyco Healthcare, Norwalk, Conn.; Fig. 15.2). The superior vesical artery is divided at its origin by means of Ligasure. The inferior vesical artery and the vesicoprostatic artery are then divided as above. The division of the pedicles is interrupted at the upper lateral aspect of the prostate to allow the preservation of the neurovascular bundles. In a non-nerve-sparing procedure the dissection is continued by means of Ligasure at this level. The neurovascular bundles on the posterolateral aspect of the prostate are easily transected in this fashion all the way down to the apex of the prostate.

15.6.3 Nerve-sparing Dissection

The nerve-sparing dissection is facilitated by the robotic approach due to the three-dimensional vision with tenfold magnification and the dexterity provided by the EndoWrist (Intuitive Surgical, Sunnyvale, Calif.). The nerve-sparing procedure is similar to the procedure during radical prostatectomy; however it is important not to accidentally transect the neurovascular bundles during the part of the cystectomy where the dissection is in close proximity to the neurovascular bundles. This is most important for the dissection close to the vesicles and the base of the prostate. The lateral aspect of the prostate is exposed and an incision in the lateral prostate down to the capsule along the whole lateral aspect of the prostate is performed. The rectum is then pushed downward with the suction cannula and the Denonvillier's fascia is transected close to the prostatic capsule. The vesicoprostatic pedicles are then taken down from the pros-

tate. Hemo-lock clips may be used in order to avoid cautery close to the neurovascular bundles. The risk of finding prostate cancer in these patients is not unlikely; however, the tumors are usually intraprostatic pT2 tumors and an intrafascial dissection plane may be used in order to facilitate a nerve-sparing procedure without risking positive surgical margins [11].

15.6.4 Apical Dissection

The vesico prostatic complex may be dissected in various ways. The use of Ligasure or the Endo-GIA with a 45-mm stapling device may be used [12]; however, we usually use a suture to secure the dorsal venous complex (2-0 Biosyn, CV25 needle). The urethra is identified and the dissection may be closer to the apical part of the prostate compared with the dissection in prostate cancer patients. A relatively long part of the urethra is dissected out before the urethra is transected. If a nerve-sparing dissection is performed, the neurovascular bundles must be protected at this level.

15.7 Female Cystectomy

15.7.1 Technique Where Four Robotic Arms Are Used

The posterior dissection of the cul de sac is performed with an inverted U incision. Vertical limbs of the incision are continued a few centimeters above the common iliac vessels bilaterally.

15.7.2 Control and Positioning of Uterus

Ovaries and uterus are removed depending on the tumor stage, the age of the patient, and the need for reproductive function. After dissection of the ureters is completed, the uterus is anteverted with the help of the fourth robotic arm. The infundibulo-pelvic suspensory ligaments along with the ovarian pedicle is identified and divided close to the uterus using either the Weck clips or the Endo-GIA with a 45-mm vascular stapler. The uterine artery pedicle can also be skeletonized and clipped or divided with the vascular stapler after it is identified and isolated. Once adequate hemostasis is achieved, the fourth robotic arm is used for retraction of the freely mobile uterus and the surrounding adnexa.

15.7.3 Control of Vascular Pedicle

The dissection of the bladder lateral to the umbilical ligaments is performed, which helps in isolating and defining the vascular pedicles. After transecting the round ligament, the superior vesical pedicle is clipped and divided using Weck clips. The bladder is retracted using the fourth arm with gentle traction, placing the vascular pedicle on stretch thereby separating and identifying the pedicle away form the external iliac ves-

sels while placing the vascular stapler through the right assistant port. The stapler with a vascular load is deployed, and after carefully identifying adequate distance from the external iliac vessels as well as the rectum, the stapler is fired and pedicle separated. Alternately, the anterior trunk of the internal iliac artery, which continues as the inferior vesical artery is dissected and the branches are identified and clipped using the Weck clips individually. The vascular pedicles may also be taken down using the Ligasure technique as described in the section on male cystectomy.

15.7.4 Vaginal Dissection

The uterus is laid on the rectosigmoid and retracted proximally with the fourth-arm assistance. The junction between the vagina and the bladder can be visually identified after filling the bladder with 100 to 150 ml of saline mixed with 5 cc of methylene blue. A sponge stick manually manipulated by the right-side assistant can help in identifying the right plane at the uterovaginal junction as well. The apex of the posterior vaginal fornix is transversely dissected at the junction of the vagina and the bladder. After passing through this layer, the sponge stick is visualized within the vaginal wall. The vaginal incision is carried anterior to either side past the urethra in a U form, ensuring that a narrow strip of anterior vaginal wall is taken en bloc with the bladder. The autonomic nerves for preservation of sexual function originate from the pelvic plexus run laterally along the vaginal wall. The excellent visualization and degree of freedom to dissect with ease helps in staying away from the perivaginal tissue within oncological norms, thereby benefiting in sexual-function preservation. If there is no history of tumor invading or approximating the uterus, hysterectomy can be performed separately. This technique is used in cases were vaginal-sparing technique is enforced to dissect the vagina carefully off the bladder. Once the bladder is removed en bloc with the anterior vaginal wall via the introitus, the uterus is lifted anteriorly and held in place with the help of the fourth robotic arm. The posterior peritoneum is incised and dissection is carried out below the vaginal fundus around the cervical insertion. The uteri with the ovaries are also removed via the vagina after placing in an endo-catch bag. In case of larger specimens, the specimen is removed via the abdominal incision after placing in the bag.

15.7.5 Mobilization of Bladder and Dissection of Urethra

Lateral dissection of the bladder has already been performed while isolating and dissecting the vascular pedicles. The dissection is further carried down to the perirectal space and followed along the curve of the pubic bone. The bladder is dissected off the anterior abdominal wall by incising the anterior peritoneum and transecting the medial umbilical ligaments and the urachus. The endopelvic fascia is opened.

The urethra is identified and a dorsal venous stitch or bipolar cautery is used to secure the venous complex. After identifying the external urethral meatus and the periurethral tissue with help of the proximal traction and manually manipulating the Foley catheter, dissection of the urethra is carried out intracorporeally to complete the urethrectomy, avoiding the need to undock the robot for accessing the vagina. When

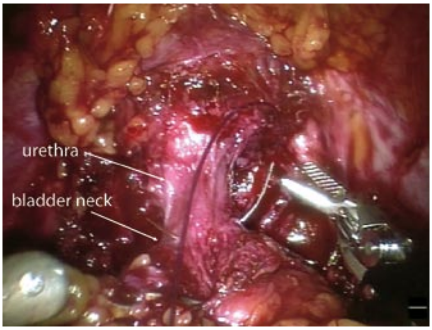

Fig. 15.3 Dissection of the urethra and bladder neck during cystectomy in a female patient where a neobladder is scheduled to be performed. Note excellent view of the urethra and bladder neck.

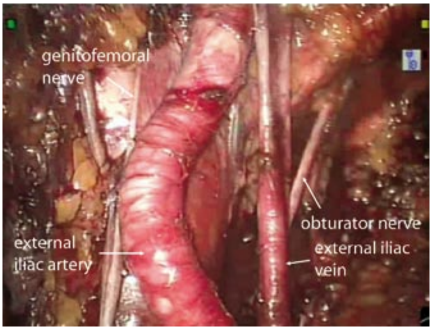

Fig. 15.4 Dissection of pelvic lymph nodes, left side. The dissection is extended medially to the perivesical area and to the genito-femoral nerve laterally. The obturator fossa is cleared of the nodal tissue while avoiding vascular or neural injury. Excellent magnification and three-dimensional vision help in precise dissection around the vessels and nerves. The dissection is facilitated by the use of 30° down lens.

the urinary diversion is a neobladder the urethra is transected just below (5 mm) the bladder neck to ensure a functional urethal closure mechanism (Fig 15.3). The vagina may be opened between the cervical insertion and the urethra in order to retrieve the specimen through the opening in the anterior vaginal wall.

15.7.6 Reconstruction of the Vaginal Wall

The edges of the vaginal wall are closed using the "clam-shell technique" with a running interlocking suture [13]. We do not perform the traditional side-to-side closure of the posterior vaginal wall, as it may produce a narrow dysfunctional tubular vagina.

15.8 Pelvic Lymph Node Dissection

The pneumoperitoneum is decreased to evaluate for adequate hemostasis prior to proceeding to a formal lymph node dissection. The lymph node dissection is performed after the bladder specimen is placed in an endo-bag and pushed away from the pelvis or retracted through the vaginal wall incision. This approach allows clear visualization of the anatomy and easy access in performing a proper lymphadenectomy. Some centers advocate performing a lymph node dissection before the cystectomy, as the

vascular pedicle is clearly isolated after a meticulous pelvic lymph node dissection. We perform the lymph node dissection after the cystectomy as it provides wide space for us to work in a narrow pelvic cavity and the identity of the vascular pedicle is easier with the phenomenal 3D vision provided with robotic assistance. Lymph node dissection is typically started distally from the nodes of cloquet and the circumflex iliac vessels. Close attention is paid to the location of the collapsed external iliac vein to avoid injury. Adequate hemostasis is obtained by using bipolar current to cauterize small vessels and lymphatic channels draining the packet.

Dissection is carried medially by identifying the obturator nerves and vessels. The dissection is extended medially to the perivesical area and to the genitofemoral nerve laterally. The obturator fossa is cleared of the nodal tissue while avoiding vascular or neural injury (Fig. 15.4). The paravesical lymph nodes are removed en bloc with the cystectomy specimen. Excellent magnification and three-dimensional vision help in

Table 15.1 Instruments used for each surgical step during female cystectomy

Surgical step	Endoscope	Right robotic instrument	Left robotic instrument	Comments
Placement of ports and lysis of adhesions	30° angled up	Scissors	Bipolar forceps	–
Dissection of ureters	0°	Scissors	Bipolar forceps	Clips placed across distal ureteo-vesical junction; frozen section performed
Positioning of uterus	0°	Monopolar scissors	Bipolar forceps	Fourth robotic arm anteverts uterus, clips placed across ovarian pedicle and uterine artery
Dissection of uterine support	0°	Monopolar scissors	Bipolar forceps	Fourth robotic arm retracts the adnexa
Control of bladder vascular pedicle	0°	Monopolar scissors	Bipolar forceps	Clips or vascular stapler placed across the vesical pedicles
Vaginal dissection	0° or 30° angled down	Scissors	Bipolar forceps	Sponge stick in vagina
Mobilization of anterior aspect of bladder	30° angled up	Monopolar scissors	Bipolar forceps	0-Vicryl CT1 around dorsal vein complex
Dissection of anterior urethra including the meatus	0°	Monopolar scissors	Bipolar forceps	–
Reconstruction of vaginal wall	0°	Needle driver	Needle driver	Clam-shell closure; 2-0 Vicryl CT2
Pelvic lymph node dissection	0° or 30° angled down	Scissors	Bipolar forceps	–

precise dissection around the vessels and nerve with ease. The dissection is facilitated by the use of 30° down lens.

Dissection is carried along the proximal portion of the common iliac artery (Fig 15.5). The common iliac artery is mobilized medially to retrieve all nodal tissue encountered. Attention needs to be paid to the amount of traction used by the robotic instruments (Table 15.1), as injuries in the area of bifurcation, especially to the internal iliac vein, can be difficult to repair. The dissection may be carried all the way up to the aortic bifurcation, removing the presacral lymphatic tissue. This will allow a lymph node dissection which is similar to the dissection in open surgery. The dissection is facilitated by placing the robotic ports a few centimeters higher up on the abdomen.

15.9 Robot-assisted Urinary Diversion

15.9.1 Robot-assisted Ileal Conduit Intracorporeal Technique

Twenty centimeters of ileum is isolated 15 cm from the ileocecal junction. The intestine may be isolated using laparoscopic Endo-GIA with a 60-mm intestinal stapler. The continuity of the small bowel is restored by using Endo-GIA with a 60-mm intestinal stapler, positioning the distal end proximal end of the ileum side to side with the antimesentery part facing each other (Fig. 15.6). The distal ends may then be closed by an additional staple row as in open surgery. Stay sutures may be used to attach the intestines before stapling them together. The left ureter is brought over to the right side under the sigmoideum. The ureteric entero-anastomosis is performed using 4-0 Biosyn with a modified Wallace technique (Fig 15.7). The ureteric stents are then introduced through the ileal segment. After the ureteric entero-anastomosis is performed, the distal end of the ileal conduit is pulled through the abdominal wall and sutured to the skin.

15.9.2 Robot-assisted Orthotopic Neobladder, Intracorporeal Technique

We create the orthotopic neobladder by using a 50-cm segment of ileum. The ileal segment is isolated and detubularized leaving a 10-cm intact proximal isoperistaltic Studer afferent limb. The continuity of the ileum is restored as described above. After detubilarization, we continue by performing the anastomosis between the urethra and the intestinal segment. This is important for two reasons: firstly, the anastomosis may be performed without tension; and secondly, the neobladder will be positioned in the small pelvis during the procedure and thus it will be relatively easy to perform the suturing necessary in the creation of the neobladder. The anastomosis is localized 10 cm from the distal end of the detubularized ileum. We use the Van Velthoven technique with a two times 18 cm 4-0 Biosyn suture allowing for 10–12 stitches (Fig. 15.8) [14]. After the anastomosis is finished, the posterior part of the Studer reservoir is sutured together using 3-0 Biosyn. In our first reservoirs we used an Endo-GIA 60-mm intestinal stapler to create the reservoir; however, this created some problems, such as tension in the urethra anastomosis, due to low compliance in the reservoir, and metallic clips may

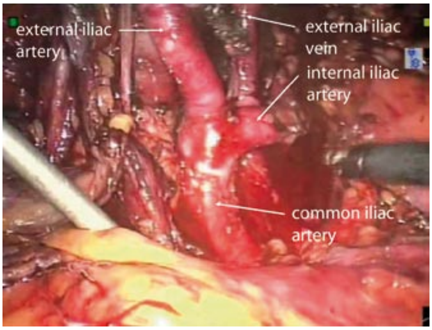

Fig. 15.5 Dissection of pelvic lymph nodes, left side. Dissection is carried along the proximal portion of the common iliac artery. The common iliac artery is mobilized medially to retrieve all nodal tissue encountered. Attention needs to be paid to the amount of traction used by the robotic instruments, as injuries in the area of bifurcation, especially to the internal iliac vein, can be difficult to repair. The dissection may be carried all the way up to the aortic bifurcation, removing the presacral lymphatic tissue. This will allow a lymph node dissection which is similar to the dissection in open surgery.

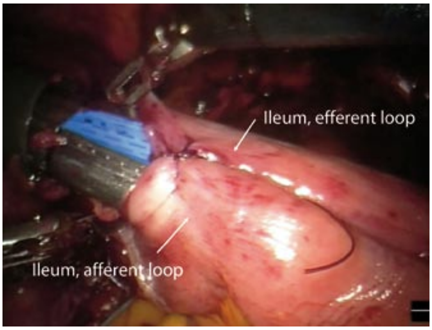

Fig. 15.6 The continuity of the small bowel is restored by using Endo-GIA with a 60-mm intestinal stapler, positioning the distal end and proximal end of the ileum side by side with the antimesentery part facing each other. The distal ends may then be closed by an additional staple row as in open surgery. Stay sutures are used to attach the intestines before stapling them together.

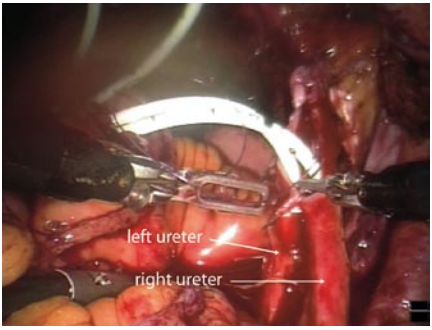

Fig. 15.7 The ureteric entero-anastomosis is performed using 4-0 Biosyn with a modified Wallace technique. The ureteric stents are then introduced through the ileal segment and in to the left and right ureters, respectively. After this the ureteric entero-anastomosis is performed using 4-0 Biosyn.

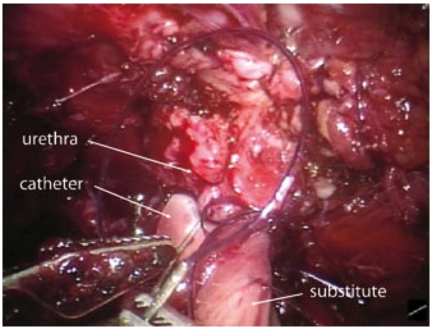

Fig. 15.8 The anastomosis between the urethra and the intestinal segment is performed before the neobladder is created. This is important for two reasons: firstly, the anastomosis may be performed without tension; and secondly the neobladder will be positioned in the small pelvis during the procedure and thus it will be relatively easy to perform the suturing necessary in the creation of the neobladder. The anastomosis is localized 10 cm from the distal end of the detubularized ileum. We use the van Velthoven technique with a two times 18-cm 4-0 Biosyn (Tyco, Norwalk, Conn.) suture allowing for 10–12 stitches.

also cause stone formation in the reservoir. After the posterior part is sutured, we continue by suturing half of the anterior part of the reservoir. At this point the anastomosis between the ureters and the afferent limb is performed using the Wallace technique as described above. The remaining part of the reservoir is then sutured.

15.10 Discussion

There are several studies which have shown that laparoscopic cystectomy may be superior to open surgery in several aspects [15, 16]. Potential advantages to perform the operation laparoscopically are smaller incisions, decreased pain, shorter recovery time, decreased blood loss and fluid imbalance, and decreased hospital stay. At present, robot-assisted cystectomy has limitations such as longer operating time, more difficult lymph node dissection, and higher cost for the procedure. Increased costs in robotic surgery has been suggested to be a major disadvantage compared with open and conventional laparoscopic surgery; however, it is notoriously complicated to calculate health care costs. The cost of the robot as well as the service fee and robotic instruments increases the expense. In contrast, shorter hospital stay, faster recuperation, and decreased bleeding will decrease costs compared with open surgery. Patients are also likely to go back to work quicker after minimally invasive approach; thus, the real costs are difficult to asses and further studies are needed to address the cost issue in minimally invasive cystectomy.

One of the main questions when performing a urinary diversion after a robot-assisted cystectomy is whether to create the urinary diversion intra- or extracorporeally? When the extracorporeal technique is used, a small incision is created allowing for specimen retrieval, restoration of the continuity of the small bowel, construction of the neobladder, and the anastomosis between the ureters and the neobladder. The reservoir is then inserted in to the abdomen and the urethra anastomosis can then be performed by laparoscopy with or without robot assistance. In contrast, in the intracorporeal technique the restoration of the small bowel continuity and the construction of the neobladder is performed without incision of the abdominal wall. In the female, the specimen may be taken out through an incision in the vaginal wall and in the male the specimen is extracted through a small incision at the end of the procedure. It is unclear if the intracorporeal technique has any advantages over extracorporeal technique. It has been argued that intracorporeal approach should only be used if specimen retrieval can be performed without an additional incision [7]. It is unclear if a totally intracorporeal technique is better for the patients. It is clearly less traumatic for the patient, but it also more technically demanding for the surgeon. The robot will make an intracorporeal technique more feasible, but nevertheless it is still a challenging surgical procedure. Performing an extensive lymph node dissection is also more complicated with the laparoscopic approach regardless of whether conventional laparoscopy or robot-assisted technique is used.

There has been a tremendous increase in the number of robot-assisted prostatectomies in the United States during the past years. During 2007 more than 50% of the operations for prostate cancer are predicted to be robot assisted; thus, the number of surgeons that are skilled users of the robot will increase over time. This will possibly also lead to an increase in the number of surgeons who may perform advanced laparo-

scopic surgery in the pelvis. Accordingly, robot-assisted cystectomy may increase due to less limitation in the number of robotic surgeons.

The advantages of robotic surgery is similar to conventional laparoscopic surgery, i.e., decreased pain, decreased hospital stay, shorter recovery time, smaller incisions. These differences are easily noted by the patients and will lead to increased demand for robot-assisted treatment. In other areas of minimally invasive surgery patient-driven demand has been a major driving force and it is possible that this will be the case also in bladder cancer surgery in the future.

The next generation of robots will probably be less expensive than current systems. New instruments that will simplify as well as allow more exact dissection will be developed. Furthermore, the possibility to combine radiology and other imaging techniques with live on-line vision systems is also likely to be developed in the near future. This is likely to increase the user friendliness of future surgical robot systems.

Finally, the long-term oncological results will define the final position of robot-assisted cystectomy in the armamentarium against bladder cancer. To date, only limited data on the oncological outcome in minimally invasive cystectomy series have been presented. The only 5-year data available suggest comparable oncological outcome for laparoscopic and open surgery [17]; however, further series with longer follow-up is needed to assess the long-term results after robot-assisted cystectomy.

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Chapter

Robotic Kidney Surgery

Jorn H. Witt

16

16.1 Introduction

Over the past 15 years laparoscopic procedures in urology have become a widely used approach for many surgical indications [8]. In many specialized centers laparoscopy is an integral part of daily practice [63]. The well-known difficult learning curve in laparoscopic procedures has led to the developments of alternatives that shorten the learning curve and improve surgical outcomes. In kidney surgery the popularity of the hand-assisted nephrectomy, especially in the U.S., is a good example for a pragmatic approach to shorten the learning process [29]. Since the introduction of telemanipolatory devices in the beginning of this decade, robot-assisted procedures have become for some indications the favored approach of many urologists. Notably, in complex reconstructive and advanced ablative surgical procedures the robot offers advances to the surgeon providing: 3D vision; 7° of motion in the hand-wristed instruments, scaling of motion and reducing of tremor [45].

The proven benefits for laparoscopic kidney surgery, compared with open procedures, such as less pain, shorter hospital stay, and faster return to normal activity and favorable cosmetic results, could also be demonstrated for robotic renal surgery [38, 89].

This chapter describes current ablative and reconstructive robotic procedures, considerations for the choice of different approaches, and the management of possible complications.

16.2 Patient Evaluation and Preparation

Evaluation and preparation for robotic kidney procedures follow the same principals as comparable standard laparoscopic or open surgery [8]. Prior to surgery possible complications, including injuries of bowel, vascular structures, nerves, spleen, pancreas, liver, diaphragm, and collective system (in nephron-sparing cases), should be discussed with the patients. Conversion to open surgery in consequence of surgical or technical reasons should also be specified [32].

There are no robotic-specific contraindications in renal surgery, but, for example, multiple prior abdominal surgery or peritonitis may influence the choice of the approach. Obese patients have a lower risk of postoperative wound or pulmonary complications in laparoscopic procedures [41]. The identification of anatomical structures could be delicate: working space may be reduced, so the possibility for conversion to open surgery is higher in obesities [78].

General laboratory and imaging studies depend on patient history. Bowel preparation is usually not mandatory but could be considered subject to the approach, prior to peritoneal surgery, and the preference of the surgeon. In dilated bowel loops, the presumption of adhesions and anticipated complex procedures, especially in transperitoneal left-side approach, we consider bowel preparation with purgative the day before surgery [63].

Depending on the disease and the procedure, special imaging and examination includes ultrasound, i.v. pyelogram, computed tomography or magnetic resonance imaging, and dynamic renal scan. Stenting of the ureter prior to the procedure can be helpful in selected cases.

16.3 General Considerations for Robotic Kidney Surgery

In addition to open and standard laparoscopic procedures, two main aspects should be focused in robotic kidney surgery: (a) robot installation; and (b) selection of the robotic instruments [51].

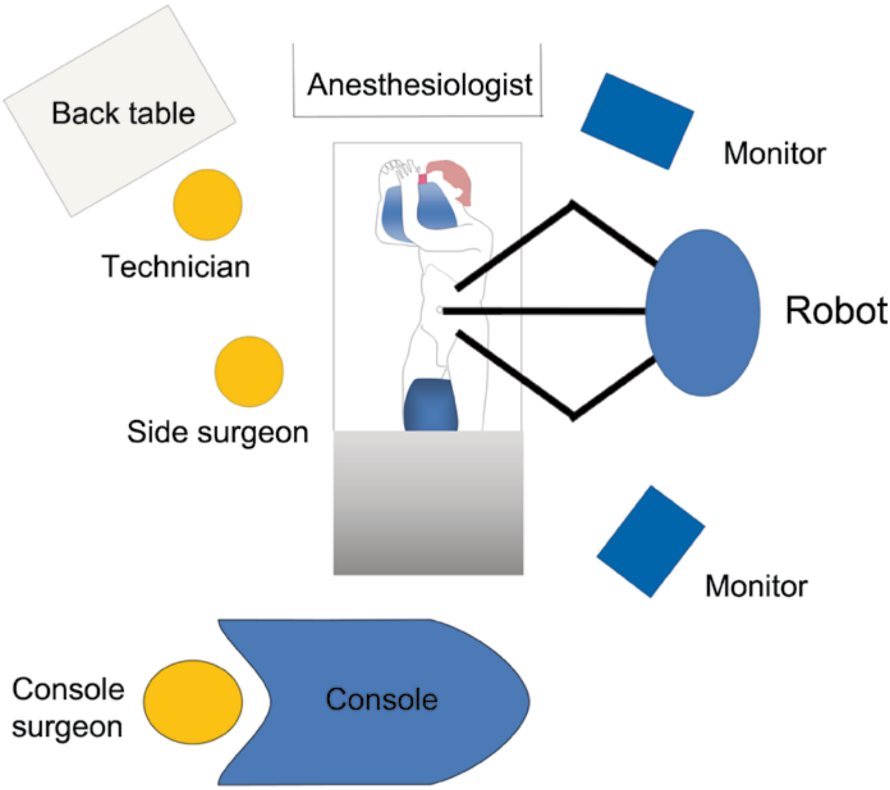

Fig. 16.1 Operating room set-up

The robot is placed on the side of the patient's back usually with the camera arm at the level of the targeted lesion. Right-angle positioning of the robot to the patient's back is used in most cases as illustrated in Fig. 16.1 [55].

Robotic procedures could be performed with a limited number of instruments. For most procedures three or four robotic instruments are adequate. Table 16.1 indicates a list of instruments used in our institution and possible alternatives. For suturing one or two needle drivers could be used depending on the preference of the surgeon. One instrument adds 200–250€/US$ to the procedure; thus, well-considered instrument selection is economically worthwhile.

Typical useful instruments are shown in Table 16.1

16.4 Surgical Approaches

As in standard laparoscopy both transperitoneal and retroperitoneal approaches are possible for robotic kidney surgery. Randomized trials have shown no significant differences between transperitoneal and retroperitoneal access regarding operative time, results, and complications, but did report a significant faster resumption of oral intake for the transperitoneal group [63]. The transperitoneal approach allows an optimal working space and more possibilities for different trocar placement. The orientation by anatomical landmarks is also easier in the transperitoneal approach [44].

Table 16.1 EndoWrist instruments for robotic renal surgery

Instrument	Alternative instrument(s)	Use	Suggested arm (sinistrals may switch position)
Typical instruments			
Monopolar curved scissors	Permanent cautery hook Curved scissors Round-tip scissors	Cutting, preparation and monopolar cautery in most procedures	Right
Large needle driver	SutuerCut needle driver	Suturing (two or in combination with Maryland)	Right or both
Fenestrated Maryland bipolar	Precise bipolar	Preparation, grasping, bipolar cautery, and suturing	Left
Harmonic curved shears	Ultrasonic shears	Kidney/pelvic preparation	Right or left
Instruments for special situations			
ProGrasp forceps	Cadiere forceps	Holding/elevating	Left
Pott scissors		Tumor excision, ureter incision	Right
DeBaky forceps		Grasping of delicate structures, suturing	Left

EndoWrist is manufactured by Intuitive Surgical (Sunnyvale, Calif.)

Retroperitoneal access needs to develop an adequate working space in the retroperitoneum before trocar placement. Identification of anatomical structures may be unfamiliar especially for surgeons who are not accustomed to this approach. For patients with a history of peritonitis, multiple prior abdominal surgery, and abnormalities of the posterior surface of the kidney the retroperitoneal access could be superior to the traditional transperitoneal approach [13, 71].

There are some reports of hand-assisted approaches combined with robotic surgery [65]. Due to handling advantages in robot technology, procedures are easier also for less experienced surgeons so that possible benefits of the hand-assisted technique are without doubt less important than in standard laparoscopy [46].

16.4.1 Transperitoneal Approach

16.4.1.1 Patient Positioning and Port Placement

In all laparoscopic procedures patient positioning and port placement are major conditions for a trouble-free target approach and a successful accomplishment of the procedure. In robotic-assisted techniques additionally the adequate distance between robotic arms for unrestricted movements and optimal placement of the robot beside the patient is essential for straightforward docking [42, 74].

The patient is placed in a modified lateral decubitus position with a 20–30° ipsilateral rotation of shoulder and hip. If desired, bending of the operating table can be done on the level of the umbilicus before securing the patient at the table. We prefer a vacuum bedding device as an inexpensive, reusable, and safe tool for proper patient positioning on the table. After securing on the table, the patient can easily be rotated to the full flank position. The complete ipsilateral flank is prepared and draped and a Foley catheter is placed in the bladder before trocar placement.

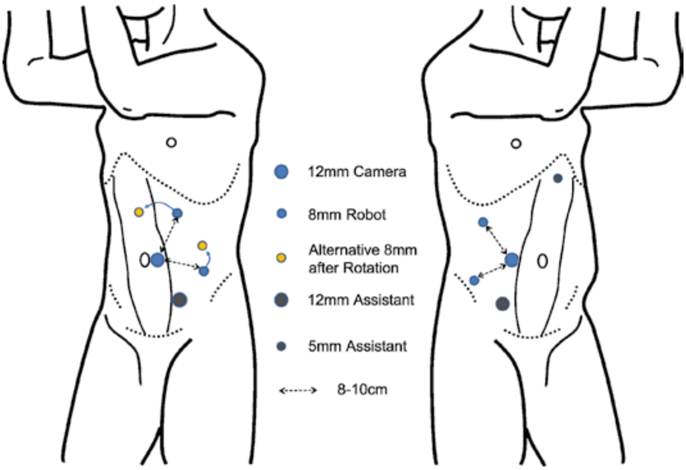

Fig. 16.2 Transperitoneal trocar placement

Figure 16.2 illustrates port positions; for insufflations we prefer the open Hasson technique. Alternatively, a Veress needle can be used. The camera port is placed pararectal at the level of the umbilicus. The two robotic arms are placed in the mid-clavicular line in a triangle fashion with the camera port. A minimum distance between the ports of 8 cm is necessary to avoid collision of the robotic arms during the procedure. The assistant port is placed pararectally between umbilicus and pubic bone. If needed, additional auxiliary ports can be placed below the xyphoid (often helpful for liver retraction in right-side kidney surgery) and below the costal arch, if possible.

Port placement for robotic laparoscopic procedures of the kidney is less straightforward than pelvic procedures [44]. The best placement of ports depends on many variables. Especially for upper-pole kidney surgery the whole set-up should be shifted upward and can be rotated. In obese patients trocars should be placed more laterally [31, 91].

Considerations, such as location of interest (upper pole, lower pole, and hilum), interference of dissection because of large organ or tumor size, distorted renal anatomy, and the individual patient's physical features affect optimized port positioning. Preoperative imaging is obligatory in the proper planning of the surgical approach.

16.4.1.2 Left-side Kidney Preparation

Using a Maryland dissector and monopolar scissors, dissection is started by incising the white line of Toldt lateral to left colon and bringing down the descending colon. Alternatively, a cautery hook or ultrasonic energy ("harmonic scalpel") can be used instead of the scissors. The mobilization of the colon should be at the same level throughout its length; cranially, the kidney should be made free to the level of the spleen, and caudally,

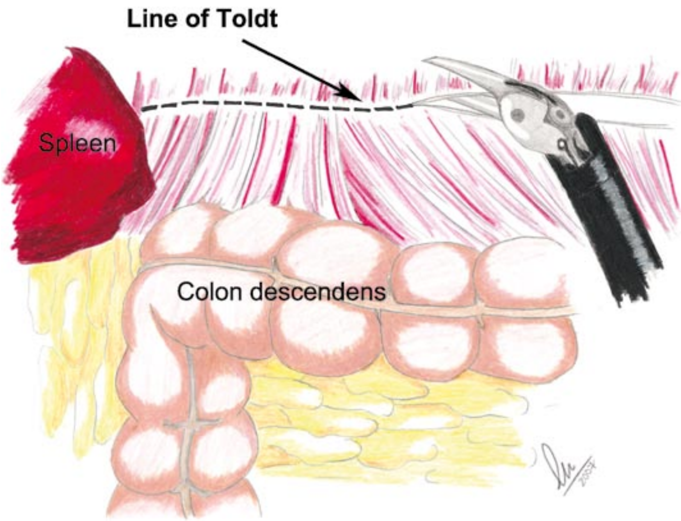

Fig. 16.3 Line of Toldt

the colon should be mobilized to the level of iliac vessels (Fig. 16.3). In cases of nephroureterectomy the sigma also has to be mobilized to follow the ureter in the pelvis. Medial traction by the assistant helps clearing of anterior Gerota's fascia by identifying additional colorenal attachments. The lienocolic and phernicocolic ligaments are incised to allow the left colic flexure to fall medially along with the pancreas.

The psoas muscle is identified and followed medially to expose gonadal vessels and ureter. The gonadal vessels, which are usually first encountered, should be swept laterally to expose the ureter. Both structures are then followed proximally to the lower pole of the kidney. Our group also prefers in ablative procedures not to divide the ureter at this point because lateral traction on ureter and lower kidney pole help to identify the renal hilum. The gonadal vein can be traced proximally to the renal vein.

16.4.1.3 Dissection and Securing of the Renal Hilum

Safe dissection of the renal hilum requires two conditions: (a) medial retraction of the colon and bowel by gravity or infrequently by an additional retractor; and (b) lateral retraction of the kidney by lifting it out of the renal fossa. Lifting the kidney to the lateral abdominal wall will place tension on the vessels, helping identify and control anticipated structures and accessory vessels. Anterior dissection is performed layer by layer with the Maryland dissector until the renal vein is uncovered. Gonadal, lumbar, and accessory venous branches can then be clipped and divided when identified. The inferior adrenal vein can be preserved when adrenalectomy is not required, but it often has to be clipped. The renal vein and artery can then be cleaned off carefully (Fig. 16.4). In most cases the artery is best approached inferior to the vein, but access from the superior position is also appropriate if easier.

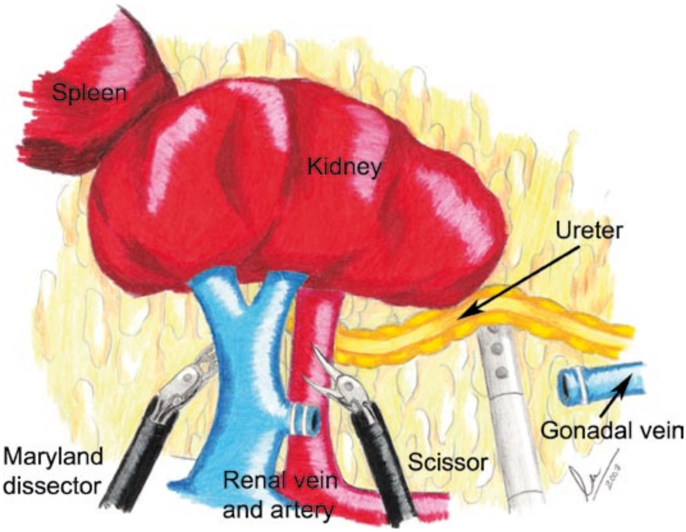

Fig. 16.4 Renal hilum

In ablative surgery the renal artery is usually divided first. Clips, stapler (endovascular gastrointestinal anastomosis = GIA staplers), or suturing can be used in robotic surgery [54, 89]. Clipping and stapler firing has to be done by the table-side surgeon. If desired, suturing of the vessels, as in open nephrectomy, is possible due to the wrist-like movements of the robotic instruments. We prefer the use of at least two Hem-o-lock clips proximal and one distally. When using GIA staplers care must be taken not to entrap clips from smaller vessels divided before [18].

For nephron-sparing procedures a laparoscopic bulldog or Satinsky clamp is used on the artery and the vein (usually in right-side procedures).

16.4.1.4 Right-side Kidney Preparation

Access to the right renal hilum is more efficient on the left side due to the fact that the right kidney is a more intraperitonally located organ. In right flank position the colon ascendance and the right colic flexure drop down usually exposing anterior surface of the kidney. Analogous to left-side preparation the line of Toldt is incised from cecum to colic flexure and gonadal vein and ureter are identified at the pelvic brim. The right gonadal vein is followed proximally to the inferior vena cava and secured and divided, if desired. By tracing the vena cava the duodenum is released and the renal vein is located. The steps in dissecting and securing of the renal vessels are similar to those previously described for the left side.

16.4.2 Retroperitoneal Approach

16.4.2.1 Patient Positioning and Port Placement

Retroperitonescopic robotic renal surgery affords, similar to open surgery, a complete, bended flank position. Available space and possible positions for port placement is nevertheless restricted compared with transperitoneal approaches. A slightly anteriorly rotation of the operation table allows the peritoneum and its content to drop away ventrally resulting in some more working space in the retroperitoneum. Two different possibilities for retroperitenoscopic port placements are shown in Fig. 16.5. The Robot is docked again from the patients back. For better right-arm docking the robot should be installed at a 45° position to the operation table when the camera port is placed over the iliac crest [89].

The first step is to create the retroperitoneal working space. A 12-mm incision is made off the tip of the twelfth rib and the index finger is used to insert bluntly through the muscle into the retroperitoneal space. By entering the correct space the surgeon should feel the lower pole of the kidney downwards, the tip of the twelfth rib upwards, and the smooth surface of the psoas muscle. Then the retroperitoneal space is created by using the middle finger of an 8½ glove mounted on a trocar or a catheter which is filled with 700–800 ml saline. Alternatively, commercial distension balloons are available [26].

Under direct vision 8-mm robotic trocars and a 12-mm camera trocar are placed using blunt tips. Again, an 8- to 10-cm right-angle setting of the robot trocars is required to allow adequate robot arm movements and to avoid arm collision. Working

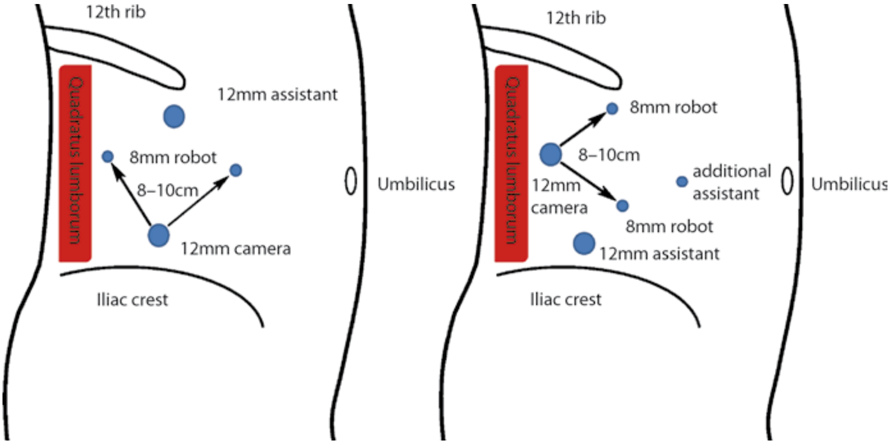

Fig. 16.5 Retroperitoneal trocar placement

space could then be extended, if necessary. The initial incision is used as the assistant port for the table-side surgeon. In case of alternative port placement, the initial incision has to be reduced by suturing for the 8-mm robot port; hybrid technique (inserting the robot port through established 12-mm port) is also possible [74].

16.4.2.2 Kidney Preparation

The orientation in the fatty tissue may be more difficult, especially in obese patients, due to unavailable typical anatomical landmarks in the beginning of the procedure. First the psoas muscle should be identified; by dissecting medially the ureter and the gonadal vein are encountered. Then the dissection of the renal hilum follows the same principals as in the transperitoneal approach. Tension on the ureter and lower kidney pole helps to identify vascular structures. The surgeon must be aware of the different direction of preparation compared with the transabdominal approach. Aorta or vena cava inferior are located perpendicularly below the ureter with the risk of accidental injuries. Access to the renal artery is usually more directly then in transperitoneal surgery. On the right-side camera orientation should be re-checked before clamping or securing the renal vein due to reports of dividing the vena cava during standard laparoscopic nephrectomy [62].

16.5 Nephrectomy

16.5.1 Simple Nephrectomy

Robotic simple nephrectomy can be used for almost all benign renal diseases that require kidney removal. Chronic pyelonephritis, obstructive or reflux nephropathy,

nephrosclerosis, and renovascular hypertension can be treated as well as symptomatic acquired renal cyst disease or symptomatic autosomal-dominant polycystic kidney disease [39, 52]. Depending on the primary disease and the duration of patient's history, inflammatory adhesions between the kidney and surrounding tissue and fibrosis of perirenal tissue "simple" nephrectomy may be a very delicate procedure.

On the left side the inferior adrenal vein can often be preserved. After controlling of renal vessels, the preparation is continued circumferentially at the upper pole by peeling of the Gerota's fascia from the kidney. The use of ultrasonic energy (ultrasonic shears or harmonic curved shears) on the left robotic arm facilitates the preparation of the upper pole and the lateral and dorsal aspect of the organ by simultaneously coagulating small vessels. The use of a Liga-Sure device by the table side surgeon is also possible but requires a good cooperation between consol and side surgeon. Preparation by bipolar Maryland dissector and monopolar hook or scissors (HotShears, Intuitive Surgical, Sunnyvale, Calif.) is also possible but is often more time-consuming.

At the end of the procedure the ureter is divided after clipping at the level of the iliac vessels. The specimen is entrapped in an endocatch bag and removed after undocking of the robot. This could be done by extending the camera trocar site at the level of the umbilicus or alternatively by widening the robot or assistant trocar site in the lower abdomen. Some surgeons prefer morcellating of the kidney inside the retrieval bag [8, 83].

A drain can be placed in the renal bed at the end of the operation, if necessary, or depending on the preferences of the surgeon.

16.5.2 Donor Nephrectomy

Donor nephrectomy follows the same principles as described for simple nephrectomy regarding some special aspects and modifying the surgical steps. Due to the length of the renal vein, the procedure is usually performed on the left side [10].

At the beginning a 7-cm midline incision is made below the umbilicus. After opening the abdominal cavity a hand port device is inserted and pneumoperitoneum is established [11]. After robot trocar placement (camera port pararectal, 8-mm robot arm ports midline between xyphoid, and umbilicus and left lower abdomen), a 12-mm assistant port is placed in the lower abdomen or below the xyphoid [45].

Before dividing renal vessels, the kidney has to be mobilized and the ureter traced below the level of the iliac artery. Care has to be taken not to compromise the ureteral blood supply by leaving a sufficient amount of periureteral fat on the ureter. After dissecting of the renal vein and dividing its tributaries (adrenal, gonadal and, if present, lumbar veins) by Liga-Sure device the artery (or arteries) are followed to its aortic take-off.

Then the ureter is clipped and divided. At this time most groups administer heparin [47]. Then artery and vein are divided by GIA stapler. The kidney is removed immediately through the hand port, on the back table staples are removed from the vessels and the kidney is flushed with preservation solution [48, 73].

After inspection the renal bed to ensure hemostasis the robot is undocked, trocars are removed, and wounds are closed, with or without leaving a drain.

16.5.3 Radical Nephrectomy

Laparoscopic radical nephrectomy has become an established and widely used procedure by many experienced centers [3, 36]. In the 2007 EAU Guidelines on renal cell carcinoma it is considered as the standard of care in patients with T1/T2 tumors. Outcome data indicate equivalent cancer-free survival rates when compared with open radical nephrectomy by reduced morbidity and less inflammatory and immunological reaction of the organism after surgery [14, 19].

The laparoscopic approach duplicates the oncological principles from open surgery [35]. In addition, port-site seeding must be avoided by using the following precautions: minimizing direct tumor handling; en-bloc resection of the tumor including surrounding tissue; entrapping all tissue in impermeable retrieval bag before removing; re-draping of port sites at time of specimen removal; avoiding of positive margins; and change of gloves for all table-site staff before wound closing [16, 28].

Robot technology allows all described steps for laparoscopic radical nephrectomy with the additional virtue of better dexterity of the instruments and 3D vision.

Preoperative evaluation is the same as in open surgery including imaging of the tumor size, possible extension in perirenal structures, and status of the vein for possible tumor thrombus and exclusion of presentable metastasis.

Patient positioning, port placement, preparation of the kidney, and dissection of the renal hilum are described in previous chapters depending on trans- or retroperitoneal approach and side of surgery.

Before dividing the vein, it should be carefully inspected if there is any question of tumor thrombus. The dissection is then performed external to Gerota's fascia at all times. Simultaneously, adrenalectomy is performed in upper-pole or large mass tumors. After dividing the inferior adrenal vein, the preparation is followed cephalad medial to the adrenal, additional veins and artery supply are identified and clipped. On the left side the tail of the pancreas should be pushed medially. On the right side an additional port for liver retraction is often necessary.

After the nephrectomy, lymphadenectomy is performed. Lymphadenectomy should be restricted to the perihilar tissue for staging purposes since extended lymphadenectomy does not improve survival. Lymphatic tissue is dissected by clips, bipolar coagulation, or ultrasonic energy. Care has to be taken of lumbar veins on the right side and of lumbar arteries on the left side to avoid bleeding complications which may be difficult to handle laparoscopically. Although lymphadenectomy is usually a limited staging procedure in renal cancer, extended robotic retroperitoneal lymphadenectomy is possible without limitation [1, 24, 80].

We always remove the intact kidney by expanding the camera port incision (alternatively the assistant port in the lower abdomen). Morcallating procedures are also described [56, 57].

16.6 Nephron-sparing Procedures

Nephron sparing or partial nephrectomy has become a widely used technique in tumors smaller than 4 cm or in patients with solitary kidney, suboptimal kidney function, or bilateral tumors [39, 58]. The largest obstacle to the widespread use of

laparoscopic partial nephrectomy is its technical difficulty. Limitation of instrument dexterity makes tumor excision, hemostasis, and reconstruction of the collecting system to a challenging procedure, even for experienced laparoscopic surgeons. Warm ischemia of the kidney is restricted to 30 min due to potential loss of renal function, so the procedure has to be performed in a quick and safe manner.

The same considerations that changed the view of both surgeons and patients about radical prostatectomy over the past years are obvious in nephron-sparing surgery. Advanced instrument movements and excellent visualization facilitates the surgeon to accomplish especially the delicate steps of this procedure [15, 33, 67].

Patient evaluation, preparation, and positioning have been described previously. In selected cases, with the expectation of an extensive repair of the collecting system, stenting of the ureter prior to surgery may be considered. Renal outside or inside cooling is usually not necessary but could be useful in special situations (e.g., large tumor in solitary kidney, central tumors).

After identifying of the ureter and aorta/vena cava, isolation of the renal vessels and mobilization of the kidney is performed as described previously. We use Maryland bipolar dissector, monopolar curved scissors, and needle driver for the entire procedure. The tumor is localized and the renal capsule is exposed with leaving perirenal fat on the specimen. Intraoperative use of a laparoscopic ultrasound probe by the table-side surgeon may help in identifying the tumor and defining the line of resection. Before clamping of the renal vessels, the line of incision is marked with the HotShears (Intuitive Surgical, Sunnyvale, Calif.) on the renal capsule. According to the size of the tumor, one or two surgical bolsters (TapoTamp, Ethicon, Norderstedt, Germany) are placed intraabdominally for later positioning in the defect. Approximately 20 min prior to clamping, 12.5 g mannitol is administered by the anesthesiologist [67, 77].

The side surgeon is clamping the renal artery (and vein in right-side procedures) with laparoscopic bulldog clamps after elevating the kidney by the console surgeon to expose and stretch the hilum (Fig. 16.6) [81, 84]. The use of a Satinsky clamp is also described but is not our preference [67].

After incision of the capsule, the tumor is excised using the scissors without electrocautery. The Maryland dissector is used for traction and exposing and coagulation of perforating arteries. The use of ultrasound energy for coagulation has also been described [88]. The suction device of the table surgeon helps by keeping the field clear of blood and exposing structures by countertraction. If a positive margin is suspected, a new, deeper plane of excision is created. Verifying the line of dissection by ultrasound probe may be helpful [50]. The excised specimen is placed beside the kidney and biopsies for frozen section are collected from the base of the lesion with the robotic scissors or a sharp grasper is handled by the side surgeon.

The base of the lesion is checked for large perforating vessels and defects in the collecting system. After replacing the scissors by a needle driver (or depending on surgeon preferences two needle drivers could be used), suturing of vessels and, if necessary, defects in the collecting system is performed with a 3/0 Vicryl on a RB-1 needle. Additional hemostasis could be achieved with an argon laser (one must be aware of the possibility of rapidly increasing intraabdominal pressure caused by cautery gas) [69, 76]. Argon-beam coagulation and other described additional forms of hemostasis (e.g., FlowSeal, Baxter Deutschland, Unterschleissheim, Germany, or TissueLink,

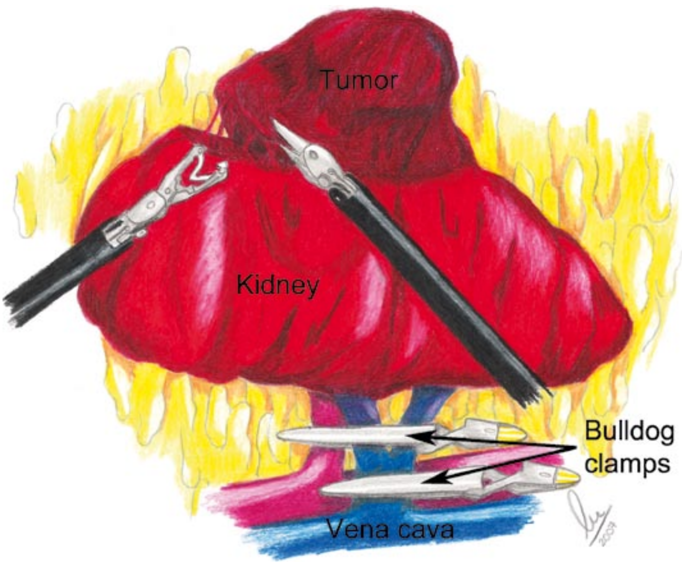

Fig. 16.6 Bulldog clamping and tumor excision

TissueLink Medical, Dover, N.H.) [68, 69, 85] are usually not necessary for adequate hemostasis in our hands. The bolsters are placed in the defect and the parenchyma is closed with 2/0 Vicryl mattress sutures on a large (CT-1) needle.

After the console surgeon elevates the kidney, the bulldog clamps are released and retrieved. Hemostasis is confirmed and perirenal fat is sutured over the defect in running technique. The tumor is placed in an endocatch bag for removal at the end of the surgery. Lateral fixation of the kidney is performed only in cases with extended kidney mobilization. We prefer to place a drain beside the defect or the hilum; in straightforward procedures or exophytic tumors drainage can be renounced. After undocking of the robot, the specimen is removed through the site of the optic trocar or the assistant trocar in the lower abdomen.

16.7 Nephroureterectomy

Indications for nephroureterectomy are upper urinary tract transitional cancer with the need of resection of a bladder cuff and hydronephrosis caused by distal ureteral obstruction without the necessity for bladder opening [8, 12].

The surgical steps for removing the kidney are described elsewhere in this book. As with other robotic renal procedures, a trans- and a retroperitoneal approach is possible. We prefer the transperitoneal approach due to easier access of the distal ureter and bladder wall. Especially when using the standard Da Vinci system the camera port should not be placed above the level of the umbilicus to avoid problems in accessing the pelvis and the ureteral orifice [64].

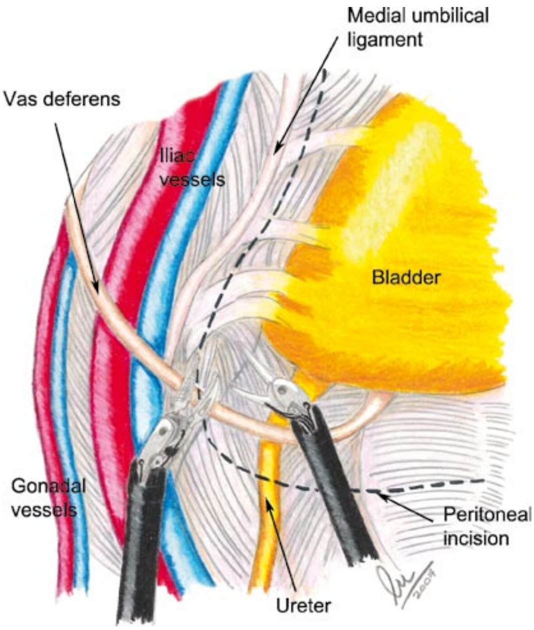

Fig. 16.7 Access of the pelvis

By following the ureter in the pelvis the peritoneum has to be incised medially or laterally to the median umbilical ligament and the vas deferens in men, or the round ligament in women is clipped or coagulated and divided as encountered (Fig. 16.7). After clipping of the ureter distal to the tumor, the ureter is dissected to its passage through the bladder wall.

The bladder is irrigated with 100 ml saline and the bladder cuff is excised with the monopolar scissors [37, 49, 60]. After replacing the scissors with the needle driver, the bladder wall is subsequently closed with a 2/0 Vicryl running suture on an SH needle. This part of the procedure is easy to perform with the robotic instruments, contrary to the standard laparoscopic approach [64].

The specimen is removed by an half Pfannenstiel incision on the side of surgery. If gaining appropriate access to the bladder wall is difficult (or if preferred by the surgeon), the procedure can also be finished with standard open technique.

16.8 Other Procedures

The experience of our group in other robotic kidney surgery is limited, just as reported in the literature. One publication demonstrated the feasibility of management of partial staghorn calculi by extended pyelolithotomy [2].

In principle, renal surgery procedures, such as nephropexy, cyst decortation, calyceal diverticulectomy, pyelolithotomy, and others, which have been publicized for

standard laparoscopy approaches [4, 5, 21, 27, 40, 43, 61, 82], should be possible in robotic kidney surgery with potential advantages due to the technology.

Besides the new technology, reasons for limited experience in infrequent kidney procedures at present may be economical aspects and the limited operation room capacity. Many centers are working to full capacity with radical prostatectomies and have only restricted robot time slots for other procedures.

16.9 Postoperative Management

As in other laparoscopic procedures, early mobilization of the patient (on the day of surgery) is recommended. Oral intake beginning on the day of procedure and return to full oral intake on day 1 or day 2 is possible, if tolerated [90]. The catheter can usually be removed on the day of surgery or on day 1, with exception of nephroureterectomy. (We check for leakage by cystogram on days 5–7.) Also, a possible drain can be removed in most patients on day 1 [72, 86].

Many patients can be discharged on day 1 and hospitalization is rarely longer than a few days.

16.10 Complications and Management

Even in the hands of most experienced surgeons, complications are an unavoidable consequence of surgical practice [8]. The patient has to understand that factors related to anatomical conditions or due to the disease, operating room environment, and technical problems could lead to such undesirable conditions. Efforts at prevention should be maximized. In case of complications, early recognition and appropriate management is necessary to avoid fatal consequences [30]. Fatal robot errors are rare; procedures can often be completed by standard laparoscopy, and in difficult situations conversion to open surgery may be considered [70].

Overall (minor and major) complication rates reported in the literature for (simple and radical) nephrectomy is between 6 and 17% [8, 53]. Complications are possible during the entire procedure, sometimes due to the surgeon or the anesthesiologist [59, 87]. Typical surgical complications include bowel injuries, solid organ injuries (liver, spleen), bleeding problems at trocar site (epigastric vessels), intra- and retroperitoneal bleeding (hilum, adrenal, mesenterial, and gonadal vessels), urine leakage, subcutaneous emphysema, and trocar-site infection [25].

Bleeding complications from renal vein or artery could be life threatening, and in doubt rapid conversion to open surgery may be necessary. In such situations robot undocking is possible in less than 1 min. Literature reports indicate that bleeding complications due to stapler or clip malfunction occur occasionally and are conditional on technical reasons and can be avoided by the following safety measures: tip of stapler or clip free of tissue; no stapling over clips; and correct stapler position with complete transaction [18].

Injuries of the diaphragm and port hernias (mostly at the site of organ removal) are less frequent. Other complications include prolonged intestinal hypomotility, (transient) skin numbness, testalgia, deep vein thrombosis/pulmonary embolism, and pneumonia [9, 20, 66, 79].

Intravascular volume overload during surgery by the anesthesiologist should be avoided due to the fact that the laparoscopic approach has far less insensible fluid loss compared with open surgery.

In case of postoperative oliguria and hemodynamic instability, bleeding should be excluded.

In contrast to recognized bowel injury, which is sutured and usually not a problem, unrecognized bowel injury may be fatal for the patient. Common causes for bowel injuries are electrocautery, Veress needle, or trocar placement [8]. We do not use monopolar energy close to the bowel, use the Hasson technique for the primary access, and place all trocars under direct vision, and, if possible, in blunt technique.

Patients with bowel injuries after laparoscopic procedures are often less symptomatic than after open surgery [7]. Patients with unrecognized bowel injury after laparoscopy typically present with persistent and increased trocar-site pain at the site closest to the bowel injury. Increasing inflammatory blood parameters and persistent bowel sounds could lead to diagnosis. Later, signs and symptoms may include nausea, diarrhea, reduced general condition, low-grade fever, and a low or normal white blood cell count. The patient's condition can rapidly deteriorate to hemodynamic instability and death if the injury is not quickly recognized and treated. Abdominal ultrasound, plain abdominal X-ray, and computed tomography are effective diagnostic imaging tools, and open exploration is usually required to evacuate bowel spillage and perform the necessary repair [7].

16.11 Future Perspectives

The new field of robotic surgery is focused currently on reconstructive and technically challenging procedures. In urology radical prostatectomy and pyeloplasty have been widespread over the past years. With growing experience in many centers there is an increasing interest in other procedures where the advantages provided by the technology could be assumed. Nephron-sparing surgery and cystectomy with urinary diversion are examples for these upcoming new points of interest [6, 23].

Especially in partial nephrectomy further developments may help to make surgery more precise. These developments could include new robotic instruments, combining of techniques such as cryoablation or radio-frequency ablation with robotic technology, and the use of virtual imaging data acquired before or during the procedure [17, 22, 34, 75].

The rapid evolution of technical possibilities will offer urological surgeons numerous new perspectives over the next years.

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Chapter

Robotic Adrenal Surgery

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17

17.1 Introduction

In the past decade, laparoscopic adrenalectomy has been established as the standard of care for benign adrenal disease [13, 16, 17, 19, 43, 49] and increasingly considered for malignant disease [34, 44, 46]. First described in 1992 [13], laparoscopic adrenalectomy has been shown to be safe, reduce patient morbidity, decrease costs, and shorten convalescence compared with open surgery [20, 26, 37, 39, 49]. Both transperitoneal and retroperitoneal approaches to laparoscopic adrenalectomy have been shown to be safe and effective [38].

Robotic-assisted laparoscopic techniques have concurrently achieved prominence in urological surgery. Robotic surgery has several potential advantages compared with laparoscopy including improved range of motion, easier instrument manipulation, stereoscopic three-dimensional vision, powerful magnification, and improved ergonomics. Robotic surgery shares many of the advantages of laparoscopy including decreased postoperative pain, shorter convalescence, and improved cosmesis. Robotic techniques have been employed in particular for urological procedures that require intracorporeal suturing and reconstruction, i.e., radical prostatectomy and pyeloplasty [30, 33]. Although adrenalectomy is an extirpative procedure that does not require reconstruction, it requires careful dissection along major vessels (i.e., aorta, renal vessels, vena cava) and intraabdominal organs (i.e., liver, spleen, kidney). By improving the speed and safety of dissection, the robot has been considered beneficial for adrenal surgery by some authors [10, 11, 45]. Also for practitioners without significant laparoscopic experience, robotic techniques may be easier to learn and more intuitive than laparoscopy, and may enable more practitioners to perform advanced minimally invasive procedures such as adrenalectomy [41].

The first robotic adrenalectomy was reported in 2001 by Horgan and Vanuno [24]. Since then, robotic adrenalectomy has been shown to be safe and feasible [45] and may have advantages in certain instances over laparoscopy [4]. Robotic techniques may facilitate identification of small and often numerous adrenal vessels [18] and visualization and dissection of the short right adrenal vein [48]. While there have been no prospective randomized studies comparing laparoscopic and robotic adrenalectomy, there have been numerous case series of robotic adrenalectomy [4, 36, 47] and comparisons between the two techniques [1, 4, 36]. While robotic adrenalectomy has not been proven superior to laparoscopy by objective data, it may be a reasonable option for selected patients, particularly at high-volume robotic centers, and may assist practitioners without substantial laparoscopic experience.

In this chapter, indications for minimally invasive adrenalectomy are reviewed, followed by a discussion of techniques for both right and left robotic adrenalectomy. Literature pertaining to robotic adrenalectomy and comparisons with the laparoscopic procedure are reviewed. Lastly, considerations for technique and training are discussed as well as the future of minimally invasive adrenal surgery.

17.2 Indications

Laparoscopic adrenalectomy has become the standard of care for benign adrenal masses and is increasingly considered for selected malignant lesions [9, 21, 34, 49]. As studies have shown that robotic adrenalectomy is safe and feasible, it may be indicated in cases where laparoscopic adrenalectomy would be performed. Indications for minimally invasive adrenalectomy are diverse and include adrenal masses >6 cm and up to 15 cm depending on surgeon skill and comfort, smaller lesions suspicious for malignancy, or in younger patients to avoid the stress of serial follow-up, lesions that increase in size on serial imaging, and hormone-secreting tumors [12, 44, 50]. Contraindications to minimally invasive adrenalectomy are controversial though typically include infiltrative adrenal masses, involvement of large vascular structures or significant involvement of adjacent organs, and tumors of large size (e.g., >10–15 cm). Disseminated metastatic disease or peritoneal carcinomatosis generally contraindicate surgical management of adrenal malignancy. There is further discussion of minimally invasive management of adrenal malignancy below.

Incidental adrenal masses are found on CT scan in up to 4% of patients [3, 23]. Numerous algorithms for evaluation and management of adrenal incidentalomas have been published [23, 50]. Decision-making regarding these lesions is based on numerous criteria including size, radiographic characteristics, and testing for secretory tumor [49].

Traditionally adrenal masses >6 cm are considered likely to harbor malignancy and should be removed, although that size threshold has been lowered to 4 cm by some authors [49]. Adrenal tumors >6 cm have 92% likelihood of malignancy [7]. Size is the best single indicator of malignancy, although its sensitivity and specificity are imperfect [44]. Younger patients may have a lower threshold for adrenalectomy based on higher lifetime risk of cancer, e.g., patients less than 50 years old with 3- to 5-cm mass may warrant adrenalectomy [15]. Size criteria for laparoscopy versus open surgery vary depending on the skill and experience of the laparoscopist as well as patient factors. Dissection of larger lesions is frequently more difficult based on increased vascularity and confined working space, and the risk of malignancy increases with the size of the adrenal tumor which may deter many surgeons from pursuing minimally invasive interventions [27].

Imaging characteristics on CT or MRI help to discriminate benign from malignant adrenal lesions. Adrenal adenomas are generally homogeneous with distinct margins compared with malignant lesions which are typically heterogeneous with irregular margins. Adenomas may be indicated by low attenuation (<10 HU) from lipid content as well as by rapid washout of contrast medium [29, 50]. Unfortunately, radiographic characteristics of benign and malignant lesions may overlap; thus, imaging tests by themselves may not be completely reliable [15, 29].

Hormonally active adrenal tumors necessitate adrenalectomy. In general, hormone secretion is investigated for lesions >1 cm [23] by a combination of history, physical exam, and laboratory testing including serum electrolytes, 24-h collection of urinary catecholamines or their breakdown products, and urinary-free cortisol [49]. Functional tumors can be subclinical and screening, even without clinical evidence, is warranted.

Minimally invasive adrenalectomy for primary or secondary adrenal malignancy is controversial, but recent literature indicates a growing willingness to treat selected lesions laparoscopically [27]. Infiltrative disease or other signs of malignancy have traditionally been considered absolute contraindications to minimally invasive resection based on the need for "radical adrenalectomy" [21, 27, 28, 44]. Radical adrenalectomy involves en-bloc resection including periadrenal fat and potentially neighboring organs. This type of resection may be feasible for selected patients in skilled laparoscopic hands, but the patient should be counseled on the possibility of conversion to open surgery. Conversion should be performed if there is any intraoperative doubt regarding completeness of resection [35]. Not disrupting the adrenal capsule and not grasping tumor or adrenal tissue is imperative if malignancy is suspected [21, 40, 44].

There is growing literature on the minimally invasive resection of isolated adrenal metastases [6]. The adrenal may be the site for metastases from lung cancer, renal cell carcinoma, melanoma, breast, and colon cancer. Adrenal metastases are generally confined to the capsule and may require simple, rather than radical, adrenalectomy for complete resection [6, 51]. Long-term disease-free survival from metastatic disease can occur following laparoscopic resection of isolated adrenal metastases [31, 32, 49], and oncological outcomes may be equivalent to the open approach for selected populations [51]. Risk of recurrence at trocar sites is minimal with no recurrences noted in several studies of laparoscopic adrenalectomy for metastasis [46].

Primary adrenal malignancy is generally considered a contraindication to minimally invasive adrenalectomy because of the high risk of locoregional recurrence [51]. There are reports of intraperitoneal dissemination and local recurrence following laparoscopic treatment of primary adrenal malignancy. It is not clear whether these resulted from tumor selection, operative technique, or other factors [6, 44]; however, if complete resection can be performed, laparoscopic resection of adrenocortical carcinoma may be equivalent to open surgery in terms of local recurrence and survival [35]. Complete resection may be difficult to achieve because of the locoregional aggressiveness of these tumors and the requirement for regional lymphadenectomy [51]. Proper staging and selection of patients with suspected malignancy are critical. Contraindications may include extensive infiltration, caval thrombus, pheochromocytoma metastatic to peri-aortic nodes, bulky locoregional lymphadenopathy, and tumors >15 cm [6, 12, 35]. Survival following laparoscopic resection of malignant tumors may improve when lesions are <5 cm [35]. Regarding the risk of port-site metastases, this risk can generally be minimized by meticulous laparoscopic technique and appropriate patient selection [35]. It is critical to follow these patients long-term for recurrence, and further prospective data regarding minimally invasive therapy for adrenal malignancy is required.

Intraoperative ultrasound may assist in staging and other aspects of minimally invasive adrenalectomy. Its potential uses include helping to locate the gland, confirm pathology, identify the adrenal vein, and examine the contralateral adrenal gland [12, 15].

Needle biopsy of an adrenal mass is not generally recommended. It may be unreliable in distinguishing malignant from benign tumors [21, 28]. Additionally, it presents the risk of hemodynamic instability from an unrecognized pheochromocytoma, adhesions making future resection more difficult, and possibly tumor seeding [21, 28].

17.3 Operative Technique

Our technique for robotic adrenalectomy is based on the transperitoneal approach with the patient in the semilateral position. We utilize the Da Vinci Surgical System. Standard preoperative precautions are taken for these patients including sequential compression devices to bilateral lower extremities, generous padding to all pressure points, and prophylactic antibiotics.

17.3.1 Right Robotic Adrenalectomy

The patient is placed in the left lateral decubitus position with proper padding of the left arm and the armboard at 90°. The right arm is placed over the left arm with appropriate padding, and the table is flexed at the level of the kidneys. The abdomen and right flank are prepped and draped. Robot, side, and console surgeon positions are outlined in Fig. 17.1, and patient positioning in Fig. 17.2. Trocar placement is illustrated in Fig. 17.3. We prefer to utilize the 30° down-angled camera, a Maryland bipolar dissector in the left hand, and hot shears in the right hand. The side surgeon uses a combination of suction, irrigation, and small bowel atraumatic graspers. In addition, the side surgeon is responsible for placing hemo-lock clips and firing the endovascular GIA when necessary.

The steps for this procedure parallel that of laparoscopic right transperitoneal adrenalectomy. The lateral attachments of the liver are incised with hot shears, and traction is placed superiorly on the liver by the assistant with the shaft of a wavy grasper, fan retractor, or genzyme triangle retractor. The posterior peritoneal attachments at the inferior edge of the liver are incised from the vena cava to the lateral side wall. The liver is further mobilized superiorly until the superior edge of the adrenal gland is identified and isolated off the underlying psoas muscle. The liver is then placed on self-retained superior retraction by either grasping the side wall with a wavy grasper and utilizing the shaft of the instrument to support the right lobe of the liver, or placing a fan or genzyme retractor to support the right lobe and securing either retractor to a self-retaining arm secured to the operative bed. Next, the colon and duodenum are identified and reflected medially using a combination of blunt and sharp dissection exposing the vena cava from the liver's inferior edge to the renal vein.

With adequate exposure now obtained and the superior adrenal gland, vena cava, and renal vein isolated as landmarks, attention is directed toward securing the adrenal vein. Note that no traction has been placed on the adrenal gland. The superior angle made by the renal vein and cava is skeletonized so that a suction probe can be placed within that angle and gentle traction placed on the adrenal gland laterally. Simultaneously, either the side surgeon or console surgeon with a Cartier forceps in the right hand retracts the vena cava medially. This opens up the space between the cava and

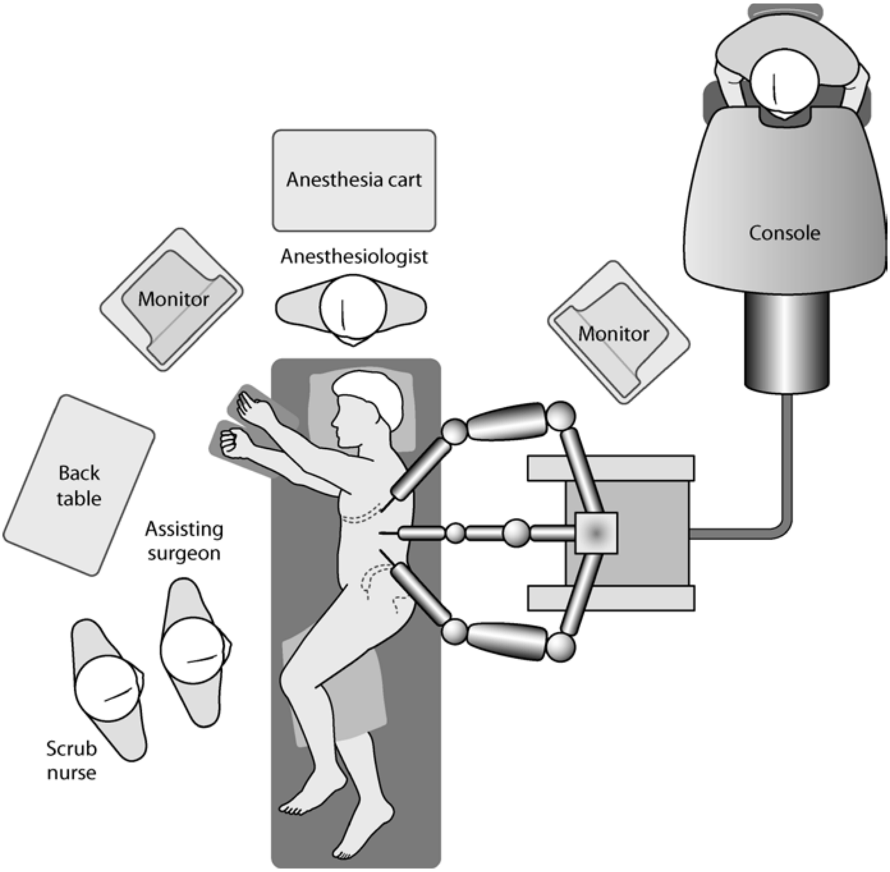

Fig. 17.1 Operating room set-up for robotic adrenalectomy

medial edge of the adrenal gland so that the adrenal vein can be identified (Fig. 17.4). Again, blunt and sharp dissection are used to open up this plane and isolate the adrenal vein. Once isolated, a Weck clip or endovascular stapler is used to secure and divide the vein.

With the medial border of the adrenal now dissected off the vena cava and the superior border dissected off the liver's edge, attention is paid to releasing posterior and inferior attachments. Gerota's fascia is incised over the upper pole of the right kidney and dissected down to the psoas muscle. At this step, the side surgeon utilizes either the ligasure or harmonic to divide these attachments as well as all posterior attachments (Fig. 17.5) while the console surgeon provides exposure with Maryland dissector and Cartier forceps. Finally, the lateral attachments are divided with either hot shears, harmonic or ligasure (Fig. 17.6). The adrenal is placed in an endocatch bag and removed from the Hassan trocar site.

Fig. 17.2 Patient positioning for robotic right adrenalectomy

Once the gland is out, the bed is reinspected for bleeding (Fig. 17.7) with pneumoperitoneum decreased to 5 mmHg, mean arterial pressure raised to 90 mmHg, and 30 mmHg of positive ventilation delivered. Once hemostasis is confirmed, all ports are removed under direct vision and closed appropriately.

17.3.2 Left Adrenalectomy

Positioning, trocar placement, and instrument preference are almost identical to the right side (Fig. 17.3). The first step is to mobilize the colon and spleen widely and medial to the aorta so that the adrenal gland and renal hilum are exposed. This is accomplished by incising the lateral peritoneal attachments of the colon on the anterior

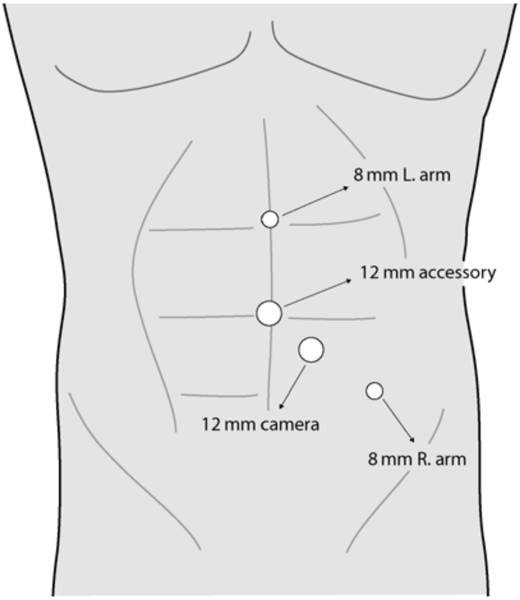

Fig. 17.3 Left trocar configuration (reverse for right)

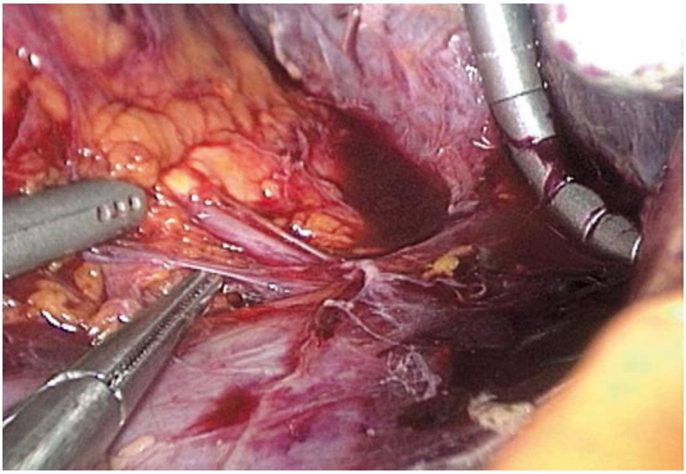

Fig. 17.4 Identification of right adrenal vein

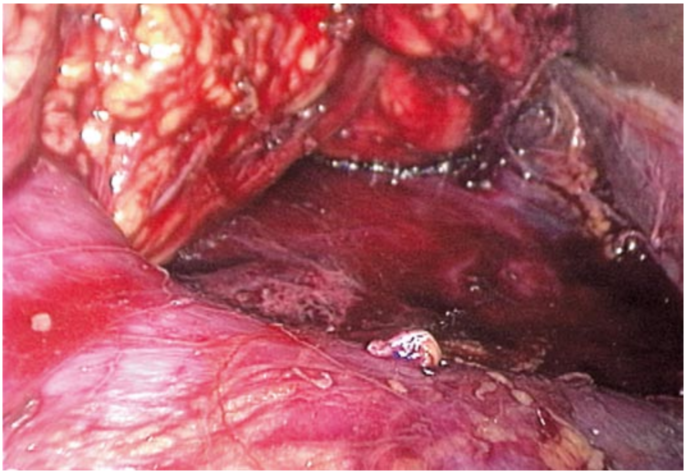

Fig. 17.5 Released superior medial and posterior attachments of right adrenal gland

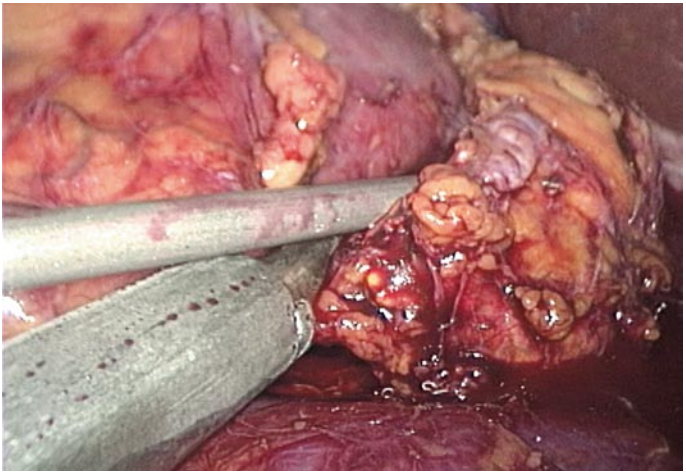

Fig. 17.6 Release of inferior attachments of right adrenal gland

surface of the kidney and exposing Gerota's fascia. The posterior peritoneal incision is carried inferiorly to the lower pole of the kidney and superiorly to the spleen and the colon is mobilized medial to the aorta with a combination of blunt and sharp dissection. The side surgeon places gentle superior traction on the spleen and the console surgeon retracts the kidney inferiorly, opening up and exposing the splenorenal attachments which are incised sharply including the lateral splenic attachments. The spleen

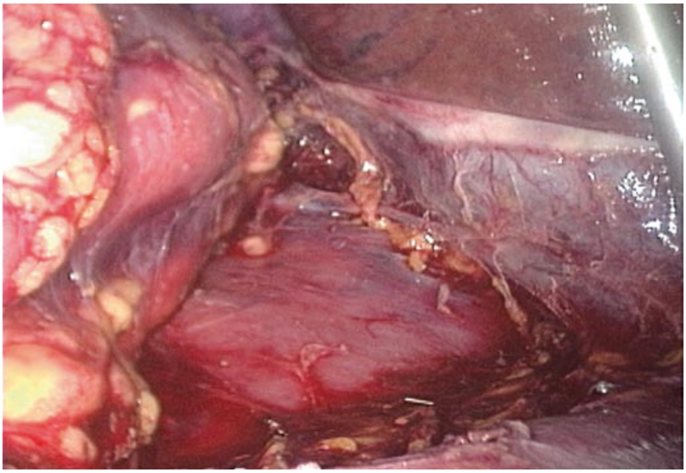

Fig. 17.7 Inspection of right adrenal bed after adrenalectomy

is mobilized superiorly and medially with a combination of blunt and sharp dissection while the side surgeon places constant medial and superior traction. Adequate exposure is obtained when the superior edge of the adrenal gland is identified and isolated off the underlying psoas muscle. The spleen is then placed on superior retraction by either grasping the side wall with a wavy grasper and utilizing the shaft of the instrument to support the spleen or placing a fan or genzyme retractor to support the spleen and securing either retractor to a self retaining arm secured to the operative bed.

With adequate exposure now obtained, attention is directed toward securing the adrenal vein. The renal vein is first identified and skeletonized. Useful landmarks to identify the renal vein are the gonadal vessel and/or aorta, or a laparoscopic Doppler probe may help to isolate its signal. Once the renal vein is isolated, the adrenal vein is easily identified entering its superior border. The adrenal vein is then divided between Weck clips or with an endovascular stapler. With the vein controlled, a suction probe can be placed within the angle between the renal and adrenal vein and gentle traction placed on the adrenal gland laterally. Simultaneously, either the side surgeon or the console surgeon with a Cartier forceps in the right hand retracts the pancreas and colon medially, opening up the medial attachment of the adrenal overlying the aorta and psoas muscle. We prefer to divide these attachments with harmonic scalpel, ligasure, or endovascular GIA since multiple vessels run in these attachments. With the medial border now dissected free and the superior border dissected off the spleen, attention is paid to releasing posterior and inferior attachments. Gerota's fascia is incised over the upper pole of the left kidney and dissected down to the psoas muscle. At this step the side surgeon utilizes either the ligasure or harmonic to divide these attachments as well as all posterior attachments while the console surgeon provides exposure with Maryland dissector and Cartier forceps. Finally, the lateral attachments are divided with hot shears, harmonic, or ligasure. The adrenal is placed in an endocatch bag and removed from the trocar site.

Once the gland is out, the bed is reinspected for bleeding with the pneumoperitoneum decreased to 5 mmHg, mean arterial pressure raised to 90 mmHg, and 30 mmHg of positive ventilation delivered. Once hemostasis is confirmed, all ports are removed under direct vision and closed appropriately.

17.4 Results

There have been numerous small case series (Table 17.1) and several comparison studies between robotic and laparoscopic adrenalectomy (Table 17.2). The number of patients in these studies has ranged from 1 to 30. Robotic adrenalectomy has been assessed in these limited series with regard to complication rate, operative time, length of stay, cost, and other variables. Comparison studies have been particularly limited in terms of patient selection, number of patients, and methodology. These studies demonstrate that robotic adrenalectomy is safe and effective, and while laparoscopic adrenalectomy is the standard of care for benign adrenal lesions, robotic techniques may provide advantages in certain settings.

Gill et al. [14] first demonstrated the feasibility of robotic adrenalectomy in an animal model. This study compared robotic adrenalectomy using AESOP and Zeus instruments in four pigs with conventional laparoscopy in three pigs. The operations were completed telerobotically from a separate room and utilized a side surgeon to change instruments and provide suction. While surgical and total operative times were significantly longer for robotic adrenalectomy, the procedure was shown to be feasible and subsequently performed in humans.

The first robotic adrenalectomy in a human subject was reported by Horgan and Vanuno in 2001 [24]. Subsequent small case series have demonstrated the safety of robotic adrenalectomy including a low intraoperative complication rate. Morino et al. [36] describe two intraoperative complications involving severe hypertension during pheochromocytoma removal. Desai et al. [11] describe an adrenal capsular tear that occurred during manipulation of the gland. Overall the complication rate between laparoscopic and robotic adrenalectomy has been approximately the same [5].

The conversion rate from robotic to open adrenalectomy has been low and comparable to the laparoscopic technique, although several robotic cases have been converted to traditional laparoscopy. Reasons for conversion have included malposition of trocars, difficulty with hemostasis, and prolonged operative time [36]. Brunaud et al. [5] noted 7% conversion rate to open for both laparoscopic and robotic adrenalectomy, for reasons including bleeding and slow progression because of polycystic kidney disease. The conversion rate may decrease with increasing experience; in Morino et al. [36], conversion decreased from 60% in the first five cases to 20% in the subsequent five.

Length of hospital stay has been shown to be equivalent between robotic and laparoscopic adrenalectomy [5]. This is not surprising given that they both confer advantages of minimally invasive surgery including decreased postoperative pain and shorter convalescence.

Studies have examined both total OR time and operative time for robotic adrenalectomy. Total OR time includes set-up and positioning of the robot which can be time-consuming in the early experience; however, robot positioning time may decrease as

Table 17.1 Published series of robotic adrenalectomy. *APA* aldosteronoma, *Pheo* pheochromocytoma, *Cush* glucocorticoid adenoma, *Aden* Adenoma, *LOS* length of stay

Reference	No. of patients	Operative time (min)	Morbidity	Conversion (%)	OR complications (%)	Median LOS (days)	APA	Pheo	Cush	Aden	Other	Cost (USD)
[47]	30	185	7	0	0	2	9	11	5	1	4	8645 (OR)
												12,977 (hospital)
[36]	10	169	20	40→lap[b]	20[d]	5.7	3	4	0	2	1	3466 (total)
[4]	19		15.8		0		8	4	5	2	0	NA
[1]	9	132.8		44→lap[c]	0	5.7	0	2	6	1	0	NA
[45]	2	118	50[a]	0	0	4				2		NA
[3]	14	111	21	7→open		6.7	5	2	4	2	1	NA
[2]	4	220	0	0	0	5	1	2	0	0	1	NA
[48]	1	100	0	0	0	1	0	0	0	0	1	NA
[11]	2	138	0	0	0	2.5	0	1	0	0	1	NA
[24]	1		0	0	0							NA

[a] Pulmonary embolism
[b] Malposition of robotic trocars (2), difficulty obtaining hemostasis (1), prolonged operative time (1)
[c] "Owing to technical difficulties"
[d] Severe intraoperative hypertension associated with pheochromocytoma

Table 17.2 Studies comparing robotic and laparoscopic adrenalectomy. *PR* prospective randomized, *PNR* prospective nonrandomized

Reference	Type	No. of patients		Mean size (cm)		LOS (days)		Operative time (min)		OR complications (%)		Morbidity (%)		Total cost (USD)[a]		Conversion (%)	
		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
[36]	PR	10	10	3.3	3.1	5.7	5.4	169	115	20	0	20	0	3467	2737	40→lap[b]	0
[4]	PNR	19	14	3.0	3.3			107	86			15.8	14.3				
[1]	PNR	9						132.8	82.1	0	0					44.4	0
[5]	PNR	14	14	3.2	3.0	6.7	6.9	111	83			28	14			7→open[c]	7→open[d]

[a] OR + hospitalization
[b] Malposition of robotic trocars (2), difficulty obtaining hemostasis (1), prolonged operative time (1)
[c] Significant bleeding from the adrenal vein
[d] Difficult dissection with a polycystic kidney

more procedures are performed [8]. Winter et al. [47] describe median robot set-up time of 4 min. Brunaud et al. [5] describe similar mean duration of operating room activity for both laparoscopic and robotic procedures. Preparation and draping time will likely improve until a plateau point with increasing experience with robotic surgery.

Operative times have generally been longer for robotic versus laparoscopic adrenalectomy [1]. Morino et al. [36] attributed longer operative times to limited robotic instruments. Transition time from laparoscopic to robotic instrumentation may improve with experience [24]. Robotic adrenalectomy may confer a time advantage for obese patients. Brunaud et al. [5] noted positive correlation between patients' body mass index and duration of laparoscopic adrenalectomy, but no correlation in patients having the robotic procedure.

Evidence suggests that costs per patient for robotic adrenalectomy may exceed costs for laparoscopic adrenalectomy [1, 36]. The cost of purchasing and maintaining robotic systems should be integrated into cost analyses. Return on investment might be improved with higher volume and multidisciplinary use of the robot. Winter et al. [47] did not show a significant difference in hospital costs comparing robotic with laparoscopic and open adrenalectomy. They attributed lower hospital charges in the minimally invasive groups to shorter hospitalizations.

Quality-of-life measures have been studied regarding robotic versus laparoscopic adrenalectomy. Brunaud et al. [4] showed that there were no major differences in quality-of-life measures including postoperative pain between the two procedures.

From a training standpoint, robotic adrenalectomy may benefit from a more rapid learning curve compared with laparoscopy [2, 22, 25, 41]. Winter et al. [47] demonstrated a 3-min improvement in operative time with each robotic adrenalectomy. Morino et al. [36] demonstrated a decrease in conversion rate from 60% in the first five cases to 20% in the subsequent five. Brunaud et al. [5] noted decreased operative time with increasing experience with the robot for adrenalectomy. Corcione et al. [9] estimated that at least ten robotic procedures were necessary to master use of the robot. Based on these observations, robotic surgery may allow urologists to apply minimally invasive techniques to adrenalectomy more rapidly than laparoscopy [25].

Further investigation is required to identify the exact advantages of robotic adrenalectomy and which patients might benefit from these techniques. The few small studies making direct comparisons between robotic and laparoscopic adrenalectomy have generally concluded that laparoscopy is superior in terms of feasibility, length of procedure, and cost [36]. As robotic systems become utilized more commonly and cost and maintenance issues become less significant, the role of robotics in adrenalectomy will likely become clearer.

17.5 Considerations

Robotic techniques may present disadvantages regarding adrenal surgery. Lack of tactile feedback may result in tissue trauma including adrenal capsular tear [11]. The surgeon is compelled to rely on visual cues, and experience is required to minimize the risk of tissue injury. Some authors argue that lack of tactile feedback is balanced by improved visibility [2].

An experienced side surgeon with laparoscopic skills is necessary to assist with access, suction, and clip application or stapling, as these instruments are not yet available

for robotic arms. This may present a disadvantage in community use of the robot for adrenalectomy.

Several tips are worthy of mention for robotic adrenalectomy:

1. For right adrenalectomy, the accessory port should be placed at sufficient distance from the camera port and robotic arm port to avoid interference [47]. If this accessory port is used, use of graspers in both robotic arms may be preferred [47].
2. Avulsion of the right adrenal vein is one of the most common causes of conversion and care should be taken in its isolation and control. A Statinsky clamp and 4-O prolene on a vascular needle with a preplaced lapra-ty should be available if caval bleeding is encountered.
3. The left adrenal vein can always be located by first identifying the renal vein. Commonly there are two adrenal branches off the left renal vein. Once isolated, the left adrenal vein is easier to divide because it is longer and narrower. Conversely, the right adrenal vein is easier to identify, but shorter, thus ligation is more challenging [47, 48]. Controlling the adrenal vein early is crucial to reduce the likelihood of injury during mobilization of gland.
4. In cases of bilateral adrenalectomy, the extreme articulation of the robotic arms may facilitate lateral and posterior dissection [1].

17.6 Conclusion

Data on robotic adrenalectomy demonstrate that the procedure is safe and feasible but not superior to laparoscopy in most cases. Certain advantages of robotic surgery (e.g., with intracorporeal suturing) do not apply to adrenalectomy, a primarily extirpative procedure. Nonetheless, the magnification and precision of robotic techniques may enable a more meticulous dissection during adrenalectomy. From a training standpoint, robotics may enable surgeons not extensively trained in laparoscopy to offer minimally invasive adrenalectomy to their patients [42].

There is need for further investigation regarding the potential advantages of robotic adrenalectomy as well as more rigorous comparison with traditional laparoscopy. The role of robotics in adrenalectomy and other minimally invasive procedures should be reevaluated over time as technology changes, e.g., advances in tactile feedback, more diverse robotic instruments, and a fourth arm [36]. High-volume robotic centers that have already invested in costs of the robot may benefit most from novel applications. These centers may make robotic adrenalectomy affordable compared with other centers [47]. Furthermore, costs of equipment and maintenance may ultimately decrease with time.

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Chapter

18

Robotic Antireflux Surgery in Children

Piet Callewaert

18.1 Introduction

Although it is well beyond the scope of this chapter to discuss in detail all aspects of the rapidly changing domain of vesicoureteric reflux (VUR), certain key elements in our present understanding of this condition need to be highlighted.

First of all, VUR remains one of the most frequent conditions in pediatric urology, although the exact prevalence is largely unknown. It is well recognized that VUR can be primary, secondary (e.g., to elevated bladder pressures in neurogenic bladders or dysfunctional voiding), and sometimes intermittent in nature. It is generally assumed that VUR predisposes to urinary tract infections and that surgical treatment of reflux and prophylactic antibiotics are equivalent in terms of preventing infections and renal scarring. The relative merit of these interventions in the natural course of these conditions remains somewhat obscure [32].

The importance of voiding dysfunction with detrusor overactivity, underactivity, or dysfunctional elimination syndrome in the etiology of VUR cannot be overestimated [4, 28]. (Conversely, high-grade VUR could in turn have a detrimental effect on bladder function.) This now generally accepted fact not only sheds a somewhat different light on the traditional distinction between primary and secondary forms of VUR but also has its implications in the treatment offered to these children; hence, bladder training and minimally invasive techniques have become more important over the years. Children with VUR and concomitant voiding dysfunction seem to suffer more breakthrough infections and have lower spontaneous resolution rates and therefore represent the majority of cases who need surgical intervention [29]. Girls, in contrast to boys, typically present at an older age, have recurrent urinary infections in combination with a degree of bladder dysfunction, and generally have lower grades of reflux [14-16, 30, 31, 33].

Antibiotics form the mainstay in the treatment of VUR, in combination with other conservative measures, because VUR spontaneously disappears in a majority of children and rarely gives rise to serious long-term complications [2]. Increasingly, however, the exact role of prophylaxis is being questioned as well-designed prospective trials are rare [9].

Nevertheless, a small subgroup of patients does pose problems of breakthrough infections and some children seem prone to renal scarring and rarely even hypertension and end-stage renal disease [12]. This brings us to the very controversial and hotly – if somewhat dogmatically – debated topic of surgical management of VUR. Looking

from a purely technical standpoint, the different open techniques offer comparable and very high success rates [11]. The (relatively) "new kid on the block" would be the endoscopic management, with different substances having been used over time [20]. Undoubtedly this is technically a very easy, relatively inexpensive, and patient-friendly treatment modality, tempting many doctors into an increasingly preemptive approach to VUR, using it as first-line treatment in cases of (antenatally detected) high-grade reflux, even in infants [25]. The tendency to use the endoscopic technique as an alternative to medical treatment is undeniably present. Success rates, even in low-grade reflux, are clearly lower than in open surgery and a second injection of bulking agent is often necessary [7]. Prospective randomized trials and long-term results are desperately awaited.

18.2 Conventional Laparoscopic Techniques in the Treatment of VUR

Both intra- and extravesical laparoscopic treatments have been described in a great variety of techniques. Most series, however, remain small and follow-up is very limited. Ehrlich et al. [6] and Janetschek et al. [13] were the first to report in 1994 and 1995, respectively, a small number of children undergoing laparoscopic Lich–Gregoir antireflux surgery for vesicoureteral reflux. Ureteral stents were deemed unnecessary. One mild unilateral stenosis later developed, requiring temporary stenting. Janetschek et al. [13] concluded that the Lich–Gregoir antireflux procedure was a complicated one because of the difficult suturing and knot tying, offering no clear advantage over the conventional procedure. The choice for a Lich–Gregoir technique for the first attempts at correction of VUR can be explained by the fact that at that time experience with laparoscopy in cavities other than the abdomen was very limited. Studies in a pig model were reported [19]. Lakshmanan and Fung reported technical modifications to minimize invasiveness [18] and a more recent paper by Riquelme et al. again reported excellent outcomes [26]. Shu et al. used this technique in young adults [27]. Laparoscopic ureteral reimplantation with extracorporeal tailoring and stenting of megaureters combined with a Lich–Gregoir type of extravesical reimplantation was recently reported by Ansari et al. [1].

Although the Cohen procedure was the more widely used in the treatment of VUR, a laparoscopic version of this type of ureteral reimplantation was investigated later than the extravesical laparoscopic techniques, the obvious reason being the anticipated difficulties with port placement and the limitations of the intravesical working space. Different approaches were used by Gill et al. [10] and Yeung et al. [34].

A recent report by Kutikov et al. [17] on either transvesical laparoscopic cross-trigonal ureteral reimplantation in patients with reflux, or a Glenn–Anderson reimplantation in patients with a primary obstructing megaureter, mentions operative success rates of 92.6 and 80%, respectively. Complications were postoperative urinary leak in 12.5% and ureteral stricture at the anastomosis in 6.3%. The authors noted that most complications occurred in the younger patients with small bladder capacities.

Chung et al. [5] described successful laparoscopic nonrefluxing ureteral reimplantation with a psoas hitch using a submucosal tunneling technique after submucosal injection of saline under cystoscopy in two female patients without postoperative com-

plications. Also in 2006, Puntambekar et al. [24] described laparoscopic extravesical ureteroneocystostomy with psoas hitch in five gynecological cases, clearly minimizing the procedural morbidity. Again no intraoperative or postoperative complications occurred.

18.3 Robotically Assisted Techniques

18.3.1 General Considerations

The holy grail in VUR would be to define very precisely and at the earliest possible point in time which group of patients with VUR is at increased risk for the complication of pyelonephritic scarring and which group is not. This would allow a very tailored approach to each individual child. In combination with knowledge of the chances for spontaneous resolution of each case of VUR, this could then lead to preemptive surgical measures in the former group, whereas for the latter group conservative management would most likely suffice. Failing this knowledge, the next best thing to aim for is to combine the superior results of time-honoured open procedures like a Cohen reimplantation or Lich–Gregoir operation with the much sought-after minimal invasiveness of laparoscopy with the added ultra-precise tissue handling and dexterity of robotic surgery. Over the last two years a few authors reported robotically assisted techniques in the treatment of higher grades of reflux, possibly adding to the confusion or controversy already outlined above [3, 22, 23].

18.3.2 Intravesical Technique

18.3.2.1 Overview

Olsen et al. were the first to experiment with a Cohen cross-trigonal ureter reimplantation by laparoscopic access to the bladder in a pig model using the Da Vinci system (Intuitive Surgical, Sunnyvale, Calif.) [21]. In all pigs the reflux disappeared after the procedure. The advantage of the robotic equipment seemed to be the better access to submucosal tunneling of the ureter and the intravesical suturing of the anastomosis. Peters and Woo [23] and Callewaert [3] in 2005 and 2006, respectively, reported their experience with robot-assisted Cohen procedures in a small number of pediatric patients.

18.3.2.2 Detailed Description of Technique

18.3.2.2.1 Patient Positioning

We place the patients in a moderate Trendelenburg position of approximately 20° at the beginning of the robotic procedure. This lets the bladder dome drop back a little and this in turn provides a space where urine can pool without hampering visualization. We also make use of that lowest point as a depot for sutures or tubes temporarily

not in use. This avoids loosing time taking these objects out of the bladder and putting them back in later. The legs of the patient are kept slightly apart to allow sterile draping with access to the bladder catheter which is used as a suction device during the procedure. Lithotomy position as for radical prostatectomy is unnecessary as the robotic device can be brought in close enough for engagement of the ports in pediatric patients. Obviously the feet of the patient need to be at the edge of the operating table.

18.3.2.2.2 Port Placement

This is the one crucial step in the procedure, the key to success or failure from the beginning and the determining element for an easy ending of the operation. A mini-Pfannenstiel incision is made at a breadth of two to three fingers above the pubic bone (slightly higher than in a traditional Pfannenstiel). The bladder is entered after applying traction sutures. The surgeon's index or little finger enters the bladder and lifts the bladder wall in a ventral and apical direction. Skin and fascia are incised and the peritoneum is swept upwards, all the time using the finger in the bladder for direction. A stay suture is placed (for easy retrieval and closure of the defect at the end of the operation) and a 5-mm Step (United States Surgical, Division of Tyco Healthcare Group, Norwalk, Conn.) radially expandable sleeve with inserted Veress needle is used to enter the bladder (Fig. 18.1). This sleeve is slightly longer than the 8-mm robotic ports and needs to be cut down about 1 cm before insertion. The robotic 8-mm port with blunt-tip obturator is inserted through the sleeve into a very shallow position in the bladder. Identical port placement is done on the contralateral side. The three incisions are made in the same skin crease. The central camera port uses another Step sleeve, this time with its own 12-mm trocar. The three ports are then lifted by the robot arms to expand the working space and limit the need for insufflation. There is no assisting port. The bladder is insufflated at low pressures of 5 mmHg.

18.3.2.2.3 Sequence of Surgical Steps

Once the three ports are secured, the rest of the procedure is very straightforward and closely mimics an open Cohen procedure. The instruments used are listed in Table 1. Insertion of a piece of 4-F feeding tube is followed by placement of a traction suture on the ureteral ostium. The suture is tied to the tube making the latter a useful handle. The mucosa is circumferentially incised around the ostium using the cautery hook (Fig. 18.2). The periureteral attachments are further taken down using the microbipolar forceps (Fig. 18.3) until the ureter does not tend to retract any longer or until peritoneum is encountered. In case the traction suture tears out, it is imperative that one immediately grab the ureter to prevent it from retracting out of view. The same piece of feeding tube is used for the other ureter. Once both ureters are freed, a submucosal tunnel connecting the most proximal part of the two mucosal incisions is created, using forceps and scissors (Fig. 18.4). The hiatus in the detrusor seems much smaller than in open surgery and is easily tightened using one stitch of Vicryl 4/0. Using the traction sutures, the ureters are each brought to their respective contralateral side through the tunnel and sutured to the detrusor. A few extra stitches usually suffice

for perfect closure of the mucosa (Fig. 18.5). For this we prefer Dexon 5/0. The piece of feeding tube (which is kept lying in the bladder dome throughout the procedure) is used to check the patency of the ureters.

18.3.2.2.4 Port-site Closure

Making good use of the traction sutures initially placed at each bladder entry site, closure of the three bladder incisions can be performed in a very controlled manner. Water tightness is checked by instilling saline through the bladder catheter. The fascia is carefully closed. No drains are needed. The skin is closed with intracutaneous sutures.

Table 18.1 Equipment used for the intravesical ureteral reimplantation with the Da Vinci Surgical System (Intuitive Surgical, Sunnyvale, Calif.)

12-mm 0° scope [a]
Two 8-mm robotic cannulae with blunt obturator
8-mm EndoWrist instruments [a]
Monopolar cautery hook
Micro-bipolar forceps
Round-tip scissors
Large needle driver
Step Veress needle 14 G [b]
12-mm Step cannula with radially expandable sleeve [b]
5-mm Step radially expandable sleeve (two) [b]

[a] Intuitive Surgical, Sunnyvale, Calif.
[b] United States Surgical, Division of Tyco Healthcare Group, Norwalk, Conn.

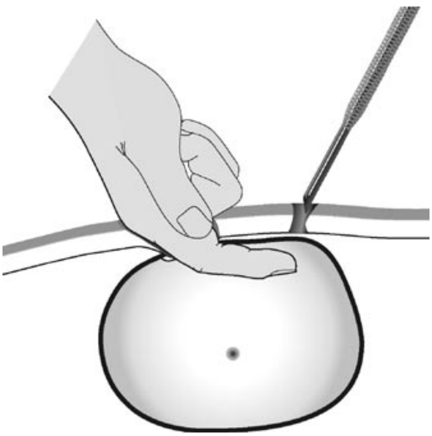

Fig. 18.1 Insertion of the Step Veress needle and sleeve into the bladder

Fig. 18.2 Incision around the ureteral ostium using cautery hook. Stay suture and feeding tube are inserted

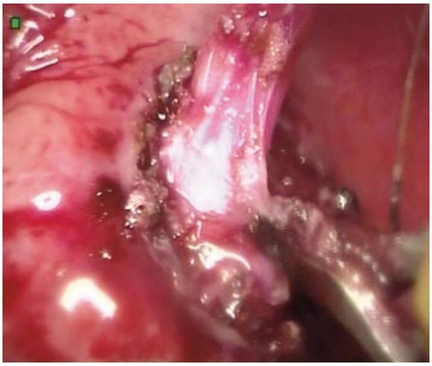

Fig. 18.3 The Endowrist Micro Bipolar Forceps (Intuitive Surgical, Sunnyvale, Calif.) is used to free the ureter more proximally

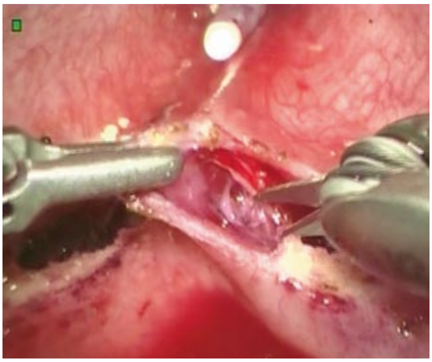

Fig. 18.4 Creation of a submucosal tunnel connecting the upper part of both periureteral incisions

18.3.2.2.5 Postoperative Management

Switch to oral pain medication on the next day. The bladder catheter is left indwelling for 24–48 h. The child is discharged on the day following catheter removal.

Fig. 18.5 Minimal trauma to the trigone at completion of the procedure

18.3.2.2.6 Results and First Impressions

Achieving an air-tight and stable, yet very shallow, port position inside the bladder is no simple task. Especially when the ports are lifted by the robotic arms to create a larger working space, the price can be that the tissues slowly slip down again no matter what happens. Small modifications to the port position during the procedure are made very awkward because the bulkiness of the arms leads to relatively uncontrolled movements. Port-related technical problems like these lead to conversion to an open procedure in 2 cases. They were both children aged 5 years but relatively small for their age. Kutikov et al. [17], using conventional laparoscopy, similarly found that the smaller children were more prone to complications and that these procedures were technically more demanding. Peters and Woo [23], on the other hand, reported no conversions in a series of six children aged between 5 and 15 years. He did, however, have a case of port-site urinary leakage requiring prolonged bladder drainage.

In our series there was one ureter with persisting grade-1 reflux out of four laparoscopically reimplanted ureters (all children were tested). This was the first case and only the cautery hook was used to free this ureter. We hypothesize that insufficient extravesical mobilization may have played a role. We subsequently found that taking down the periureteral attachments works much quicker and is more controlled when using the microbipolar forceps (Fig. 18.3). Conceivably it should be safer as well. Peters and Woo [23] reported one case of persisting low-grade reflux.

Creation of the submucosal tunnel and reimplantation of the ureters is remarkably easy because of the three-dimensional visualization and great dexterity inside the very small volume of the bladder. The anatomical detail is such that disecting the layer between detrusor and mucosa is achieved with more detail than in open surgery (Fig. 18.4).

Slight and temporary postoperative dilatation of pelves and calices was seen in all kidneys.

In contrast to the technique recently published by Peters and Woo [23], we placed our three trocars in the same skin crease. This may have reduced the working space to a certain extent but has the advantage of keeping all scars within the “bikini line” and in case of conversion to an open procedure no extra incision is visible.

Bladder spasms remained completely absent and anticholinergics were unnecessary. This fact is highly suggestive of the minimal invasiveness and limited trauma incurred by the bladder wall (Fig. 18.5).

18.3.3 Extravesical Technique

18.3.3.1 Overview

Ehrlich et al. [6] and Janetschek et al. [13] pioneered the first Lich–Gregoir operations in 1994 and 1995, respectively, but their technique was difficult and not widely adopted. Peters and Borer [22] later reported the first robotic cases.

18.3.3.2 Detailed Description of Technique

18.3.3.2.1 Patient Positioning

Similar to the intravesical operation a moderate Trendelenburg position is chosen to make access to the pelvic cavity easier by keeping bowel from dropping back towards the retrovesical space.

18.3.3.2.2 Port Placement

Straightforward placement of the camera port in the umbilicus and of the two working ports is implemented. The umbilical port is placed right in the center of the umbilicus to achieve a small scar and an 8-mm port is placed in each lower abdominal quadrant. Again the radially expandable Step sleeve is used to minimize the scar. The three ports are slightly lifted by the robot arms. There is no assisting port, hence no suction. The abdomen is insufflated at pressures of 10–12 mmHg. The 30° scope is used throughout the procedure. (Instruments used: Table 2)

Table 18.2 Equipment used for the extravesical approach with the Da Vinci Surgical System (Intuitive Surgical, Sunnyvale, Calif.)

12-mm 30° scope
Two 8-mm robotic cannulae with sharp obturator
8-mm EndoWrist Instruments
Monopolar cautery hook
Micro-bipolar forceps
Round-tip scissors
Large needle driver
12-mm Step cannula with radially expandable sleeve [a]

[a] United States Surgical, Division of Tyco Healthcare Group, Norwalk, Conn.

18.3.3.2.3 Sequence of Surgical Steps

A small transverse peritoneal incision is made on the laterodorsal side of the bladder and the retroperitoneum is entered very carefully. The search for the ureter is performed using cautery hook and microbipolar forceps. It should be possible to find the ureter using only a minimum of coagulation, but any bleeding needs to be prevented to guarantee perfect visualization and gentle handling of the tissues (Fig. 18.6). The ureter is freed circumferentially and the periureteral tissues are taken down using the microbipolar forceps. The ureter can be followed down to the ureterovesical junction without the need to enter the space behind. The 30° scope that, until this time, was used looking "down" toward the ureter is now turned 180° to look "up" toward the bladder. At this point two traction sutures are placed transcutaneously using 3- or 4-cm straight needles to stretch and expose the dorsal side of the bladder where the trough in the detrusor muscle is to be made. Care is taken to choose as natural a course for the ureter as possible. The bladder is slightly distended with saline and the detrusor is incised using the cautery hook, moving in a caudal direction. The mucosa soon reveals itself as a bulging bluish smooth surface (Fig. 18.7). This plane is developed down to the ureterovesical junction. At this point the bladder is partly emptied in or-

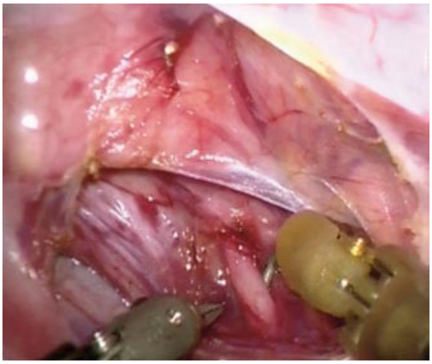

Fig. 18.6 Identification of the right ureter close to the ureterovesical junction

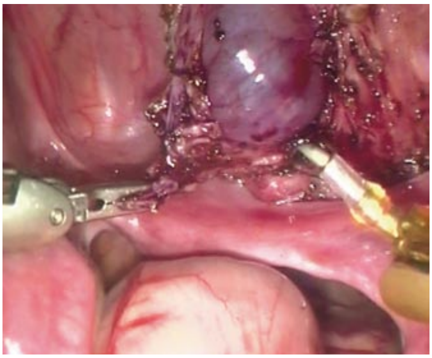

Fig. 18.7 Careful incision of the detrusor causing the mucosa to bulge

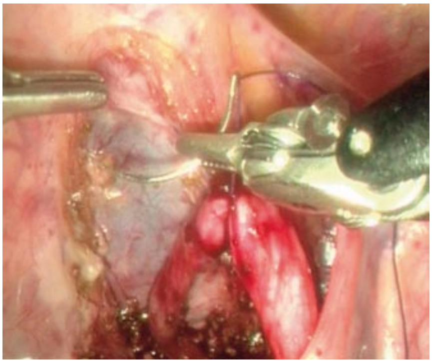

Fig. 18.8 The first suture hinging the completely freed ureter into the trough and re-approximating the detrusor

der to take down the last strands of detrusor muscle, extending the incision slightly in an inverted-Y fashion. The ureter is then buried in the trough using four or five interrupted sutures (Fig. 18.8). After removal of the two traction sutures, the bladder drops back to its natural position. Water tightness is checked and the peritoneum covering the bladder is closed with a running suture. The bladder catheter is removed at the end of the procedure unless a significant perforation needing suturing of the mucosa has been made (this happened once).

18.3.3.2.4 Postoperative Management

In the absence of a bladder catheter voiding is checked regularly. Oral intake is resumed on the first postoperative day. Patients were generally discharged 1 day later. Renal ultrasound was done at regular intervals on an outpatient basis.

18.3.3.2.5 Results and First Impressions

Ages in this small group ranged from 3 to 10 years, with one (exceptional) adult patient. There were no bladder symptoms in any of the 7 patients. No complications occurred. Recovery was remarkably quick, the earliest discharge from hospital having taken place 20 h after surgery. One ureter showed persisting reflux which was, however, "downgraded" from grade IV to a nondilating grade II, and there was one case of "de novo" contralateral low-grade reflux. A conservative approach was chosen for both as spontaneous resolution seems likely. Like in the Cohen procedure, most pelves showed minor dilatation on careful follow-up with ultrasound. This resolved spontaneously. No technical difficulties were encountered when using this technique in 2 cases of complete duplication of the ureters.

One procedure was successfully executed in a 66-year-old man after a failed subureteral injection for painful symptomatic reflux.

Unlike the situation in intravesical procedures, there were no technical difficulties with port placement. The abdominal cavity, even in smaller children, is large enough to allow comfortable movement of the instruments.

18.4 Discussion and Conclusion

Treatment modalities of reflux are evolving rapidly. Robotically assisted laparoscopic techniques must be considered a possible future alternative to the more traditional ways of treating this condition. There is no proven superiority at this time and experience is limited to only a few centers and relatively small numbers of patients. Robotics certainly add to the precision and ease of most surgical steps when compared with conventional laparoscopy. As demonstrated, we adopted two different approaches, starting out with the Cohen-type operation and later adding the extravesical technique. The intravesical approach is feasible, but technical difficulties must be taken into account in smaller children. The extravesical approach clearly seems the more promising, even in adult patients and possibly after failed submucosal injection therapy. Similarly, Elmore et al. [9] recently reported on the use of the open Lich–Gregoir technique as salvage in these cases. In our experience the Lich–Gregoir technique offers the following advantages over the intravesical operation: no need for catheters; no hematuria; and it seems more readily reproducible. The drawback is that the abdominal cavity needs to be entered. Nevertheless, we feel that the intravesical approach deserves further pursuing because it may allow surgical correction of other malformations at the level of the bladder neck and ureterovesical junction in a minimally invasive and very precise way. The issue of postoperative scars remains undecided in our opinion: either three slightly larger scars in the suprapubic region in case of the Cohen procedure, or three smaller scars (umbilical and two flank incisions) of which only the two lateral scars remain visible (Figs. 18.9, 18.10).

Fig. 18.9 Scars 1 month after intravesical Cohen repair

Fig. 18.10 Scars 3 weeks after extravesical left-sided procedure

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Chapter 19

Economic Aspects of Starting a Da Vinci Robotic Surgery Program

Roland Peplinski and Ryan Rhodes

19.1 Introduction

Today's leading hospitals have maintained profitability in an increasingly competitive environment by expanding their minimally invasive surgery (MIS) programs. The Da Vinci Surgical System is a requisite investment and a strong foundation for any minimally invasive surgery (MIS) initiative. The Da Vinci system is without question the most technologically advanced surgical platform available in the present market. Hospital executives invest in the Da Vinci system to capture market share, create a competitive advantage, and fulfill the institution's mission to be the community's leading health care provider.

When conducting an acquisition assessment for the Da Vinci system, hospital executives analyze the cost of the acquisition within the context of what benefits the technology will offer patients, surgeons, their institution, and the community. The purpose of this chapter is to enumerate the potential benefits of the Da Vinci Surgical System as an investment in future profitability.

19.2 Description of the Technology

The concept of surgical robotics was little more than a medical curiosity until 1999, the year Intuitive Surgical (Sunnyvale, Calif.) introduced the Da Vinci Surgical System. Intuitive Surgical is presently the global leader in the rapidly emerging category of Da Vinci surgery – robotic-assisted, computer-enhanced minimally invasive surgery. Since its inception, the company's mission has been to provide surgeons and hospitals with the tools needed to expand the benefits of minimally invasive surgery to the broadest possible range of patients – thereby improving clinical outcomes and helping patients return more quickly to active and productive lives.

Intuitive Surgical serves customers throughout the world, providing technology and procedural innovation across cardiac, urology, gynecological, pediatric, and general surgical disciplines.

Since its first Da Vinci shipment, Intuitive Surgical has expanded its installed base to more than 800 academic and community hospital sites, while sustaining growth in excess of 25% annually. Intuitive Surgical is proud to be fulfilling its mission to extend

the benefits of MIS to the broadest possible range of patients, while providing extraordinary value for its customers, investors, and employees.

The Da Vinci Surgical System consists of an ergonomically designed surgeon's console, a patient-side cart with four interactive robotic arms, a high-performance vision system, and proprietary EndoWrist instruments. Powered by state-of-the-art robotic technology, the Da Vinci scales, filters, and seamlessly translates the surgeon's hand movements into precise movements of the EndoWrist instruments. For surgeons, the Da Vinci system offers superior 3D visualization, enhanced dexterity, greater surgical precision, and ergonomic comfort. For hospitals, the Da Vinci Surgical System enables the clinical and economic benefits of MIS to be applied to a broader base of surgical patients.

19.3 Hospital Resources: Broad Economic Impact

A sound technology acquisition model seeks to align net health outcomes with the economic value of innovation. When costs and benefits are weighed together, technological advances over time have proved to be worth far more than their costs.

A technology assessment of the *Da Vinci* Surgical System will demonstrate broad hospital-wide benefit in the areas of market share growth, utilization mix, and productivity.

19.3.1 Market Share Growth and Maximizing Efficiency

With regard to market share growth (Figs. 19.1, 19.2; Table 19.1), there are (a) increased patient satisfaction, (b) new patients and increased referrals, (c) recruitment

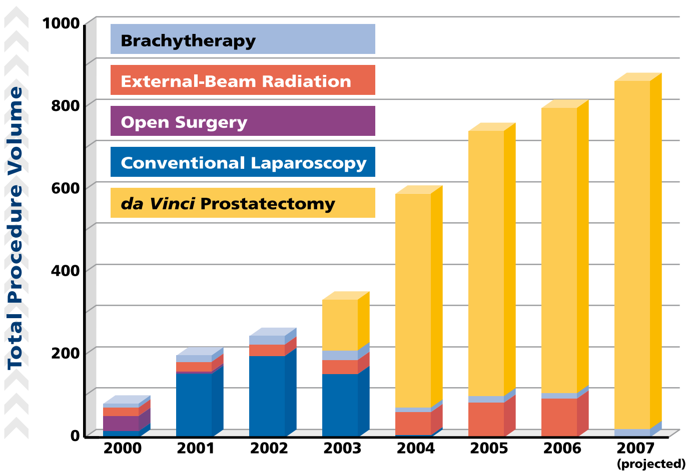

Fig. 19.1 Market share growth case studies: total procedure volume

and retention of top surgical talent, and (d) enhanced hospital reputation. With regard to maximizing efficiency, there are (a) decreased length of hospital stay, (b) decreased complications, (c) decreased blood transfusions, (d) decreased nursing staff ratios, and (e) decreased postoperative pain management.

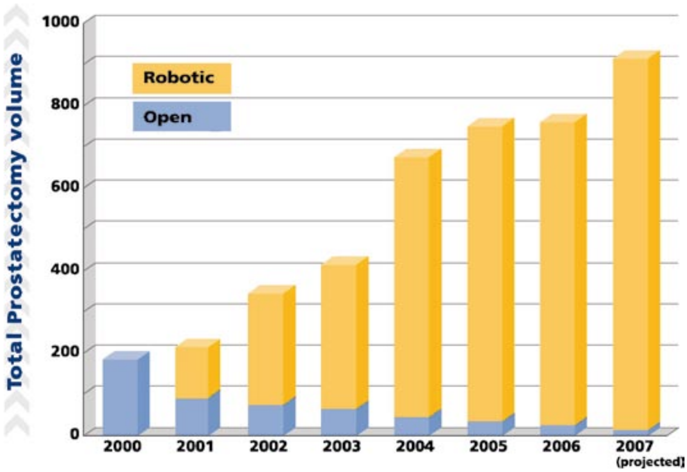

Fig. 19.2 Market share growth case studies: total prostatectomy volume

Table 19.1 Market share growth case studies

Small community hospital						
Dallas–Fort Worth metropolitan area, 25 beds						
		2003	2004	2005	2006	2007 (projected)
		63	308	386	657	775
Regional cancer center						
Southern California, 165 beds						
		2003	2004	2005	2006	2007 (projected)
		123	519	643	692	844
Large Metropolitan Medical Center						
Detroit metropolitan area, 903 beds						
2001	2002	2003	2004	2005	2006	2007 (projected)
125	270	350	630	715	735	900

19.3.2 Clinical Validation

In the late 1980s, an investment in laparoscopic surgery (MIS) led to unprecedented clinical and economic benefits. Despite the proliferation of laparoscopic technology within the hospital, adoption of laparoscopic techniques, for the most part, has been limited to routine procedures such as cholecystectomy, Nissen fundoplication and appendectomy. With the extended capabilities offered by robotic technology, leading cardiothoracic, urological, gynecological, general, and pediatric surgeons around the world have adopted the Da Vinci Surgical System.

19.3.2.1 Urology Procedures

The Da Vinci Prostatectomy (dVP) is rapidly becoming the standard of care for the treatment of prostate cancer. In a prospective comparison of conventional "open" prostatectomy (RRP) and laparoscopic prostatectomy (LRP), dVP was found to yield superior cancer control while significantly reducing the incidence of impotence and urinary incontinence [1–5]. Additionally, dVP patients benefited from fewer complications, reduced need for blood transfusions and a dramatic reduction in overall length of stay [5–8].

Commonly performed Da Vinci urology procedures include: (a) radical prostatectomy; (b) nephrectomy; (c) ureteral reimplantation; (d) pyeloplasty; and (e) radical cystectomy.

19.3.2.2 Cardiothoracic Procedures

In cardiothoracic surgery, the Da Vinci system enables surgeons to complete complex maneuvers without ever placing their hands within the patient's chest cavity. With the Da Vinci system, patients avoid sternotomy, experience fewer postoperative complications, benefit from a reduced length of stay, as well as a significantly faster return to normal function [5, 6].

In a prospective, multicenter study comparing traditional mitral valve repair (MVR) with robotically assisted MVR, patients receiving robotically assisted MVR benefited from fewer complications, a lower mortality rate, and a significantly reduced length of stay [3].

Moreover, the Da Vinci system enables a higher rate of mitral valve repair versus replacement. Repair provides patients with reduced risk of surgical complications [8], higher long-term survival [9–12], improved heart function and strength [8], more freedom from reoperation [13], fewer complications [8], no need for life-long blood-thinner medication, and shorter hospital stay [8].

Commonly performed Da Vinci cardiothoracic procedures include: (a) mitral valve repair; (b) cardiac tissue ablation; (c) internal mammary artery mobilization; (d) atrial septic defect repair; and (e) mammary to left anterior descending coronary artery anastomosis for cardiac revascularization with adjunctive mediastinotomy.

19.3.2.3 Gynecological Procedures

Since receiving U.S. Food and Drug Administration approval in 2005, Da Vinci Hysterectomy (dVH) has received widespread attention as a promising new approach that can overcome many of the technical limitations of conventional laparoscopy. Complex portions of the operation, such as securing the uterine arteries and cardinal ligaments, performing an accurate culdotomy, and oversewing the vaginal cuff, are performed with greater ease, thus providing unique advantages as compared with conventional laparoscopy.

Furthermore, by offering superior visualization, enhanced dexterity, greater precision, and ergonomic comfort, Da Vinci makes it possible for gynecological oncologists to perform a precise, complete, MIS for early-stage cancer.

In addition, the Da Vinci system enables Da Vinci Myomectomy, the most advanced surgical technique for the treatment of uterine fibroids. Da Vinci enables meticulous dissection and enucleation and a precise, three-layer suture reconstruction of the uterus, thus creating a new, minimally invasive option for the management of leiomyomata.

Finally, Da Vinci has also proved promising in sacrocolpopexy, a procedure that treats uterine or vaginal vault prolapse. Presently, approximately 200,000 women have prolapse surgery each year [14]. Most of these surgeries are performed via laparotomy. This may be because sacrocolpopexy involves difficult dissections and extensive suturing, both of which are difficult to perform with conventional laparoscopy. Da Vinci can provide surgeons greater ability to visualize and dissect the vaginal vault and sacral promontory for more accurate graft attachment, more precise and faster suturing of the graft material to the anterior–posterior vaginal wall and to the anterior surface of the sacrum, as well as greater suturing ease and speed to retroperitonealize the graft.

Commonly performed Da Vinci gynecological procedures include: (a) Da Vinci Hysterectomy for benign conditions; (b) Da Vinci Myomectomy; (c) Da Vinci Hysterectomy for early-stage gynecological cancer; and (d) Da Vinci Sacrocolpopexy.

19.3.2.4 General/Pediatric Surgery Procedures

To date, the complexity of certain laparoscopic procedures has influenced the rate of adoption by surgeons. With the Da Vinci system, complex surgical procedures previously not amenable to a minimally invasive approach can now be performed safely and effectively with fewer complications, reduced length of stay, and improved outcomes [15, 16].

In a comparison of laparoscopic to robotically assisted Heller myotomy, patients undergoing the robotically assisted myotomy approach benefited from 0% mucosal perforations, a potentially serious complication associated with the procedure [17]. Furthermore, complex cancer operations, such as pancreatic resection, transhiatal esophagectomy, and colon and gastric resection, are now being performed minimally invasively with the Da Vinci system [18–20].

Commonly performed general and pediatric procedures include: (a) Heller myotomy; (b) splenectomy; (c) Nissen fundoplication; (d) gastric bypass; (e) donor nephrectomy; (f) bowel resection; (g) adrenalectomy; and (h) cholecystectomy.

19.3.2.5 Universal Patient Benefits

The clinical evidence of value from MIS is well known. With the Da Vinci system, these widely accepted outcomes are now applicable to a broader base of surgical patients. Universal patient benefits regardless of surgical specialty may include:
1. Reduced length of stay
2. Less blood loss and subsequent need for transfusion
3. Less postoperative pain and discomfort
4. Less risk of infection
5. Faster recovery and return to normal daily activity
6. Improved cosmesis
7. Higher patient satisfaction

19.3.3 Business Model

It is well known that hospitals and health care systems are high fixed-cost organizations. The majority of costs in providing hospital services are related to buildings, equipment, labor, and overhead, which are fixed over the short term. In a landmark 1999 study, published in the "New England Journal of Medicine," investigators found that in a large metropolitan hospital, 80% of the hospital's costs were fixed [21]. In such an institution, roughly 80 cents from each incremental revenue euro or dollar drops to the bottom line; therefore, the contribution margin from an incremental patient has a very positive impact on the bottom line. Conversely, a drop in patient volume has the opposite effect.

The key to improving profitability in a high fixed-cost environment is revenue growth. In a recent survey of hospital executives, the actuarial firm, Tower Perrin, found that the operating room is responsible for 20–40% of a hospital's costs; however, 68% of the hospital's annual revenues were related to surgery [22]. If the operating rooms are responsible for generating the majority of an institution's revenues, then the greatest potential for profitability rests within the OR.

The Da Vinci Surgical System can contribute to the hospital's pursuit of profitability in three distinct ways:
1. Market share growth: The Da Vinci system can attract new patients, new referrals, and new hospital revenue.
2. Length-of-stay savings: The Da Vinci system can immediately reduce length of stay for a broader base of surgical patients who can now benefit from a minimally invasive procedure.
3. Operating efficiency: The Da Vinci system can immediately reduce the incidence of surgical complications, postoperative infections, blood transfusions, postoperative pain management, and simplifies postoperative nursing care.

Successfully moving innovative technology into the mainstream of patient care requires close collaboration between the manufacturer and hospital. Intuitive Surgical is prepared to offer a full breadth of corporate resources to help our customers achieve their strategic objectives. To this end, the following resources are available to all Da Vinci system customers:

1. The Reimbursement Hotline, +1-888-868-4647 x3128, is available to answer questions regarding considerations, coverage decisions, technology assessments, and reimbursement experiences.
2. Intuitive Surgical's Comprehensive Clinical Training Continuum helps ensure optimal safety, efficacy, and utilization of each Da Vinci system.
3. Intuitive Surgical representatives can facilitate program implementation for new hospital accounts. We can provide marketing support, including source files for a variety of promotional materials, and we work with hospital and practice marketing staff to coordinate promotional events.

19.3.4 Market Analysis

The primary investment value of the Da Vinci Surgical System is growing the hospital's market share with new surgical referrals from its primary, secondary, and tertiary service areas. Market analysis offers the hospital's executive team a framework to assess the hospital's competitive positioning in the marketplace by understanding:

1. The hospital's potential market by Metropolitan Statistical Areas, geographical draw from cities, and specific hospital competitors
2. The hospital's potential market share for frequently performed Da Vinci surgical procedures
3. The hospital's historical surgical track record for these procedures
4. The hospital's potential to attract new business in these procedures after the Da Vinci Surgical System is installed and the hospital has taken full advantage of Intuitive Surgical's comprehensive marketing programs

19.3.5 Cost Analysis

The next investment value of the Da Vinci Surgical System is reduced system-wide costs from improved patient outcomes known to occur with minimally invasive surgery. Reductions in length of stay and postoperative nursing requirements can result in significant cost savings each year. A region-of-interest analysis is designed to show how the Da Vinci Surgical System will reduce the hospital's costs by reducing the length of stay for commonly performed surgical procedures.

The direct costs associated with Da Vinci procedures include the cost of the EndoWrist instruments and the cost of an annual service agreement. With regard to the EndoWrist instruments, the OR supply budget must be adjusted to match the forecasted growth by surgical specialty. Hospitals that view their operating room as a profit center recognize that these direct costs are proportional to the total number of Da Vinci procedures performed annually. The more surgical procedures performed, the lower the incremental cost per procedure.

While clinical studies support the effectiveness of the *da Vinci*® System when used in minimally invasive surgery, individual results may vary. Surgery with the *da Vinci* Surgical System may not be appropriate for every individual. Patients should always ask their doctors about all treatment options, as well as their risks and benefits.

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